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See advertisement page 19.
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AUTOMATIC FEED REGULATORS.
And Auxiliary Machinery as supplied to the Admiralty. 2179

Dredging Plant
OF ALL DESCRIPTIONS.
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See half-page Advert. last week and next week. 2087

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See Advertisement last week, page 19.

Spencer-Hopwood & Kirke
PATENT BOILERS *See Page* 10. 1994
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Specification and Workmanship equal to Main Line Locomotives.
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Tubes and Fittings.
Sole Licensees in Great Britain for the manufacture of "Armco" Rust and Corrosion Resisting Iron Tubes. 2257
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HEAD OFFICE: 34, Robertson Street, Glasgow.
See Advertisement, pages 33 and 91, Oct. 24.

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PASSENGER AND CARGO STEAMERS.
SHALLOW DRAFT VESSELS. 2276

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Worm Wheels cut up to 13 ft. diam.
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Builders of RAILWAY CARRIAGES, WAGONS ELECTRIC CARS, and EVERY OTHER DESCRIPTION OF RAILWAY and TRAMWAY ROLLING STOCK.
Makers of WHEELS and AXLES, RAILWAY PLANT, FORGINGS, SMITH WORK, IRON & BRASS CASTINGS.
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Systems
PRESSURE, AIR, STEAM
For Boilers of all types.
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Naval Outfits a Speciality,
also for Merchant Ships, for Factories, Locomotives, and Industrial Process Furnaces of all kinds.
Supplied to the British and other Governments.
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New Wire Ropes,
Half price.
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Gearing of all Descriptions.
GEAR WHEELS up to 10 ft. diameter.
FLY ROPE and SPUR DRIVING WHEELS up to 28 ft. diameter.
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Makers of
Evaporating and Distilling Plants.
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Fresh Water Distillers.
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Auxiliary Surface Condensers,
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MECHANICAL ENGINEERS,
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Undertake SPECIAL MACHINE WORK of any description.
WELL EQUIPPED SHOP.
LATHE WORK up to 10 ft. diameter.
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Boilers, Tanks, & Mooring Buoys
STILLS, PETROL TANKS, AIR RECEIVERS, STEEL CHIMNEYS, RIVETED STEAM AND VENTILATING PIPES, HOPPERS, SPECIAL WORK, REPAIRS OF ALL KINDS.

IRON & STEEL
Tubes AND Fittings AND Steel Plates.
STEWARTS AND LLOYDS, Ltd.
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See Advertisement, page 51. 1872

Peter Brotherhood Ltd.,
PETERBOROUGH.
STEAM ENGINES AND TURBINES.
GAS AND OIL ENGINES.
AIR COMPRESSORS.
REFRIGERATING PLANT. 1475
See Advertisement, page 51, Oct 24.

MACHINE CUT
Gears.
Spurs, Bevels.
Spiral, Worm and Worm Wheels.
HIGHFIELD GEAR CUTTING CO.
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Huddersfield. 1645

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Cornish Boiler 20 ft. by 6 ft., 100 lbs. w.p. G 2
HARRY H. GARDAM & CO., LIMITED, Staines.

Overhead Electric Two-ton RUNWAY (New) FOR SALE, Herbert Morris, cage operated, packed as just delivered, 230 feet with one bend, approximate height 28 feet. With or without 3 phase Motors 220 volts. Magnificent plant. Will sell at 25 per cent. sacrifice.—Apply, C. L. STIFF & CO., LTD., Slag Breakers, East Ardsley, near Wakefield. F 672

Electric Transporters.
S. H. HEYWOOD & CO., LTD., 1357
REDDISH.

Generating Set, Crude Oil, by Robey-E.C.C. 20 Kw., 220 volts D.C., Date 1919.
HARRY H. GARDAM & CO., LIMITED, Staines. G 173

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Meadow Hall Works, Sheffield,
Railway, Colliery, Mining and General Engineers, are PREPARED
to UNDERTAKE the MANUFACTURE of NEW SPECIALITIES
suited to their plant and tools.
No financing of patents. Only serious business entertained.
Address confidential enquiries to the 2404
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Gas Engines Inspected, Tested and Reported upon. Over 25 years' experience. Tel.: Maryland 1736 & 1737. Wire: "Rapidising, London."—Great Eastern Road, Stratford, E.15. 1794

Laboratory Equipment for Metallography.
The "DAVON" Pat. Super-Microscope.
"Capable of remarkable work"—*Dr. Rogers.*
"Ease of manipulation in high power work." Moderate cost. Brochure "C" with photographic specimens free from:—
F. DAVIDSON & Co., 29, Gt. Portland St., London, W.1.

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ENGINEERS, IRLAM, MANCHESTER.
FEED WATER HEATERS,
CALORIFIERS, EVAPORATORS, } ROW'S PATENTS,
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SYPHONIA STEAM TRAPS, REDUCING VALVES.
High-class GUNMETAL STEAM FITTINGS.
WATER SOFTENING and FILTERING. M723

YARROW & CO. (1922), LTD., GLASGOW.
LAND AND MARINE
YARROW BOILERS. 2277

Matthew Paul & Co., Ltd., 2212
LEVENFORD WORKS, Dumbarton.
See Full Page Advt., page 44, Oct. 10.

Forgings.
Walter Somers, Limited,
HALESOWEN. 7116

Taylor & Challen Presses
For Production of SHEET METAL WORK, COINAGE, CARTRIDGES AND GUNPOWDER.
Foundry, Works and Showrooms: BIRMINGHAM.
See Advert., page 79, Oct. 10. 8195

Head, Wrightson & Co.,
LIMITED.
See Advertisement page 52. 2402

Railway Switches and Crossings.
T. SUMMERSON & SONS, LIMITED, DARLINGTON. 2006

The Glasgow Railway Engineering Company,
GOVAN, GLASGOW. LTD.,
London Office—12, Victoria Street, S.W.
MANUFACTURERS OF
RAILWAY CARRIAGE, WAGON & TRAMWAY WHEELS & AXLES.
CARRIAGE & WAGON IRONWORK, also CAST-STEEL AXLE BOXES. 1948

Locomotive Traversers (ELECTRIC).
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BUILDERS of RAILWAY CARRIAGES & WAGONS
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Special designs only.
"Circulation Theory."
Akimoff Propeller Company,
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Telephone: 7424 Central.
E. P. Alexander & Son.
CHARTERED PATENT AGENTS,
306, High Holborn, London, W.C.1. 585
PATENTS. DESIGNS. TRADE MARKS.

The Manchester Steam Users' Association.

For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, Mount Street, Manchester.

Chief Engineer: C. E. Stromeyer, M.I.C.E.

Founded 1854 by Sir William Fairbairn.

Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 2005

Correspondence Courses for

Inst. Civil Engrs., Inst. Mech. E., London Univ. (Matric., Inter., B.Sc.), Inst. M. & Cy. E., and ALL ENGINEERING EXAMINATIONS personally conducted by Mr. TREVOR W. PHILLIPS, B.Sc. (Honours) Eng. London, Assoc. M. Inst. C.E., Chartered Civil Engineer. M.R.S.I., F.R.S.A., etc. Also Day Tuition in Office. Excellent results at all Exams., comprising hundreds of successful Students. Courses may commence at any time, and all Students receive individual tuition.—For full particulars apply to 8/11, Trafford Chambers, 58, South John Street, Liverpool. 1993

The Institution of Mechanical Engineers.

THOMAS HAWKSLEY LECTURE, 1924.

Engineer Vice-Admiral Sir George R. G. Goodwin, K.C.B., LL.D., Member of Council, will deliver the above Lecture on

"The Trend of Development of Marine Propelling Machinery,"

at the Institution, Storey's Gate, Westminster, on Friday, 7th November, 1924, at SIX p.m.

Visitors are invited.

The Lecture will be repeated in Leeds on 11th November, and in Birmingham on the 11th December. G 220

THE WORSHIPFUL COMPANY OF FANMAKERS.

The Worshipful Company of

Fanmakers have instituted an ANNUAL COMPETITION for promoting the study of modern methods of ventilation, for which they will award a Silver Medal for an Essay adjudged the best by their assessors:—

John W. Cooling, M.Sc. (Tech.), A.M.I.Mech.E.
Alan E. Munby, F.R.I.B.A. and
H. D. Searles-Wood, F.R.I.B.A.

The Subject selected for 1924-25 is

"The Ventilation of a Police Court."

Competitors must be of British Nationality, not over 25 years of age.

Particulars and Conditions of the Competition may be obtained by written application to

Hugh D. P. Francis, Esq., M.A.,
Clerk to
The Worshipful Company of Fanmakers,
62, London Wall,
London, E.C.2. G 233

Engineering Salesmanship

and Sales Management.—Write for brochure describing our special Course of Training for posts of unlimited scope in this lucrative field.—Director, Institute of Engineering Salesmanship, 333, Oxford Road, Manchester. 2431

Engineering Drawing.—

Special Postal Course in Engineering Drafting. Enrol now. Fee Three Guineas for the complete course. Also day tuition in Office by qualified teacher. Established in 1895.—Percy Pitman, M.I.Mech.E., 25, Victoria Street, London, S.W.1. 2297

TENDERS.

TO ENGINEERS, MACHINERY MERCHANTS AND OTHERS.

For Sale, by Private Bargain,

the COMPLETE MACHINE TOOL EQUIPMENT of WALLACE (Glasgow), LIMITED, Engineers, Cardonald, Glasgow.

The Machine Shop, which covers several acres, was completely equipped with Up-to-Date Machine Tools in 1920.

Offers for the whole or part will be received by the Subscribers up till Twelve o'clock Noon on Friday the 14th day of November, 1924, who will supply fully descriptive Catalogues and Forms and Conditions of Tender, together with Cards to View.

Alexander Murdoch, C.A.,
53, Bothwell Street,
Glasgow.

James Winning, C.A.,
93, West George Street,
Glasgow,
Liquidators.

24th October, 1924. G 224

VICTORIAN STATE RAILWAYS.

THE AGENT GENERAL FOR VICTORIA, AUSTRALIA, invites

Tenders for the Purchase,

F.O.B. Melbourne, of the following:—

TWO SECOND-HAND 500 K.W. TURBO ALTERNATORS, 2100 volts Single Phase, 50 Cycles, 3000 r.p.m., together with Switches, Condensers and Spare Parts. Both sets in good running condition.

Specifications of the Plant, conditions of Contract and Forms of Tender may be obtained by *bona fide* Tenderers at the Offices of the Consulting Engineers, Messrs. John Coates & Co., Ltd., Victoria House, Melbourne Place, Strand, London, W.C.2.

Tenders must be delivered to THE AGENT GENERAL FOR VICTORIA, Victoria House, Melbourne Place, Strand, London, W.C.2, not later than Eleven a.m. on Monday, November 17th, 1924, marked:—

"Tender for Turbo Alternators."

A preliminary deposit of five per cent. (5%) of the total amount of the Tender must accompany each Tender.

The Government does not bind itself to accept the lowest or any Tender.

(Signed) George Fairbairn,
Agent General for Victoria,
Australia.

Victorian Government Office,
London. G 234

HIGH CARLEY SANATORIUM, near ULVERSTON.

For Sale, Vertical Boiler.

OFFERS are REQUIRED for a VERTICAL BOILER, size 10 ft. 6 in. by 3 ft. 6 in. Working pressure insured at 80 lbs per square inch. The boiler can be seen on application to the Medical Superintendent.

Offers to be sent to Dr. G. Lissant Cox, Central Tuberculosis Officer, County Offices, Preston. G 264

The Director-General,

India Store Department, Branch No. 16, Belvedere Road, Lambeth, S.E.1, REQUIRES:—

PLANING MACHINES

for stone dressing, canting arm and Portland types, wire saw heads with tension gear, direction or guide posts and three-strand wire for stone cutting.

Tenders due on the 14th November, 1924.

Tender forms obtainable from above. G 260

STATE ELECTRICITY COMMISSION OF VICTORIA.
Melbourne,
Victoria,
AUSTRALIA.

Tenders are Hereby

Invited for the SUPPLY, DELIVERY, etc., of the following for the Yallourn Power Scheme.

Copies of Tender Form and Specification will be available upon application to:—

AGENT GENERAL FOR VICTORIA,
Melbourne Place, Strand,
London, W.C.2.

Specification No. 24/114—
SWITCHGEAR AND ACCESSORIES.

Charge:—£2 2s. for the first three copies of Tender Form, Conditions of Contract, Specification and Drawings complete. This charge will be returned on receipt of a *bona fide* Tender. A fourth copy and any further copies will be supplied for the sum of 10s. 6d. each. This charge is not returnable.

Preliminary Deposit:—A Preliminary Deposit of £100 is to be lodged with Tender.

The Specification may be inspected at the above mentioned office.

The Commission does not bind itself to accept the lowest or any Tender.

Tenders on prescribed form, properly endorsed and addressed must be delivered to the undersigned in Melbourne not later than Noon, 20th December, 1924.

R. Liddelow,
Secretary. G 179

PORT OF BRISTOL.

THREE 9-TON STEAM CRANES FOR GRABBING.

The Docks Committee invite

Tenders for the Construction

of THREE 9-TON STEAM CRANES for Grabbing. The contract includes the erection of the cranes on a Grab Hopper Dredger now in course of construction.

On and after Monday the 3rd day of November, 1924, copies of the specification etc., can be obtained from the undersigned on production of a receipt to the undersigned showing that a deposit of £5 has been paid to the BRISTOL DOCKS COMMITTEE, TO WHOM ALL CHEQUES MUST BE SENT AND MADE PAYABLE. The deposit will be returned to *bona fide* tenderers after the receipt of the Tender with all the prescribed documents and drawings.

The Tender must be enclosed in a sealed envelope endorsed "Tender for Steam Cranes" and addressed to the General Manager and Secretary of the Bristol Docks Committee, 18, Queen Square, Bristol, and must be delivered to him accompanied by all the prescribed documents and drawings before Ten a.m. on Monday, the 1st December, 1924.

The Docks Committee do not bind themselves to accept the lowest or any Tender.

Thomas A. Peace,
Chief Engineer.

Chief Engineer's Office,
Avonmouth Dock,
Bristol.
28th October, 1924. G 265

THE SOUTH INDIAN RAILWAY COMPANY, LIMITED,
are prepared to receive

Tenders for the Supply of:—

1. Lamp Glasses and Fittings.
2. Plate Glass, etc.
3. Brushes.
4. Wicks, etc.
5. Asbestos.
6. Locks.
7. Galvanized Sheets.
8. Belting.
9. Steel Work for Bridges (Perok & Kallayi).
10. Bogie Steel Ballast Wagons.

Specifications and Forms of Tender will be available at the Company's Offices, 91, Petty France, Westminster, S.W.1.

Tenders addressed to the Chairman and Directors of the South Indian Railway Company, Limited, marked:—"Tender for Lamp Glasses and Fittings," or as the case may be, must be left with the undersigned not later than Twelve Noon on Friday, the 14th November, 1924, for Specifications Nos. 1, 2, 3, 4, 5, 6, 7, and 8, and on Friday, the 2nd January, 1925, for Specifications Nos 9 and 10.

The Directors do not bind themselves to accept the lowest or any Tender.

A charge, which will not be returned, will be made of:—

For each copy of Specification No.	£	s.	d.
1.		5	0
2, 3, 4, 5, 6, 7.		2	6
8.			Free.
9.	1	0	0
10.	10	0	0

Copies of the Drawings may be obtained at the Offices of the Company's Consulting Engineers, Messrs. Robert White & Partners, of 3, Victoria Street, Westminster, S.W.1.

A. Muirhead,
Managing Director.

91, Petty France, S.W.1.
29th October, 1924. G 272

APPOINTMENTS OPEN.

COUNTY BOROUGH OF WOLVERHAMPTON.
MUNICIPAL SCIENCE AND TECHNICAL SCHOOL.

Principal:—W. E. Fisher, D.Sc., A.M.I.M.E.

APPOINTMENT OF ENGINEERING LECTURER.

Applications Invited for Post

of RESPONSIBLE SENIOR LECTURER of Mechanical and Electrical Engineering Department. Person appointed will undertake special responsibility in connection with organisation of major engineering courses. Instruction at present given almost wholly in evening classes. Well-equipped engineering laboratories are in course of construction as first section of new Technical College.

Candidates must hold engineering degree or equivalent, and must have had adequate works experience.

Salary in accordance with Burnham (Technical) Scale, with allowance of £50 for special responsibility. Further Particulars and form of application, to be returned by 15th November, 1924, may be obtained by sending stamped foolscap envelope to undersigned.

T. A. Warren,
Director of Education.

Education Offices,
North Street,
Wolverhampton. G 222

BOARD OF TRADE.

STANDARDS DEPARTMENT.

A Vacancy Exists for a

CHIEF ASSIZER in the Standards Department of the Board of Trade, with establishment in His Majesty's Civil Service after two years approved service. The duties consist principally in the maintenance and care of the standards and apparatus belonging to the Department and in the periodical examination and verification of the standards and equipment in use by Inspectors of Weights and Measures. In the latter connection the appointed candidate will be required to visit Inspectors' offices throughout the country. Subsistence and travelling allowances on the usual scales will be paid.

Candidates who must be British subjects by birth, and the sons of fathers also British subjects by birth, should have had full theoretical and practical training, and be fully conversant with the construction, adjustment, and use of all types of weighing and measuring appliances. Experience as an Inspector of Weights and Measures is a desirable qualification and may be taken into consideration in fixing the starting salary. Preference will be given to Ex-service men.

The Salary scale is £180, rising by £10 to £300 per annum, with bonus which is re-assessed half-yearly on the basis of the average cost-of-living figure for the previous six months. The present bonus on £180 is £99 4s.

Application with particulars of experience and copies of testimonials should be made in writing to the PRINCIPAL ESTABLISHMENT OFFICER, Board of Trade, Great George Street, Westminster, S.W.1, not later than the 15th November, 1924. G 247

KENT EDUCATION COMMITTEE.

BRITH TECHNICAL INSTITUTE.

Required Immediately,

TEMPORARY FULL-TIME TEACHER of Machine Design and Elementary Physics to Day and Evening Students. Salary will be in accordance with the Burnham Scale.

Particulars of qualifications and experience should be sent immediately to the Principal, Technical Institute, Brith Road, Belvedere, Kent.

E. Salter Davies,
Director of Education.

25th October, 1924. G 230

COUNTY BOROUGH OF BLACKBURN.

APPOINTMENT OF MECHANICAL ENGINEER.

Applications from Qualified

Persons are INVITED for the above APPOINTMENT, a list of the duties of which may be obtained on application.

Salary, £4 10s. per week, inclusive.

Applications (on forms to be obtained from my Office) should be sent to me not later than November 6th, 1924, accompanied by copies of three recent testimonials.

Canvassing will be a disqualification.

(Signed) A. T. Gooseman, M.Inst.C.E.,
Borough and Water Engineer.

Town Hall,
Blackburn.
October, 1924. G 226

Skilled Calculator (Male

or Female) with ability to carry out long computations, REQUIRED for the Royal Airship Works, Cardington. Candidates must possess a University degree in science or engineering and have taken higher mathematics in degree examination. Experience in stressing of complicated braced structures essential, preferably in connection with design of aircraft. Preference to candidates with knowledge of aerodynamics.—Apply, giving full particulars of experience and qualifications, and stating salary required (male candidates should state war service, if any), to THE SECRETARY, Royal Airship Works, Cardington, Beds. G 231

COUNTY OF LONDON ELECTRICAL SUPPLY COMPANY, LIMITED.
BARKING POWER STATION.

Applications are Invited for

FOUR JUNIOR SWITCHBOARD ATTENDANTS for Barking Power Station. Plant installed 100,000 Kw.

Preference will be given to applicants having had previous similar experience, in any case experience of the operation of a modern power station is essential.

Applications, with copies of recent testimonials, should be sent on or before 5th November to the MANAGER and SECRETARY, County of London Electric Supply Co., Ltd., Moorgate Court, Moorgate Place, E.C.2.

The salary offered will depend upon the qualifications and experience of the candidates selected. G 243

Experienced and Energetic

SALESMAN (Engineer) with good connections in industrial circles REQUIRED for the LONDON OFFICE of a large Swiss Engineering Firm, for pushing the sale of Steam Turbines, Compressors, Water Turbines, Pumps, Paper-making Machineries, etc.—Applications, stating age, full experience and qualifications and salary required, also enclosing photo and testimonials, should be addressed to BOX 190, c/o Hooper & Batty, Ltd., 15, Walbrook, London, E.C.4. G 269

Shipyard Manager Wanted

to take entire charge under general management; must have experience in estimating, designing and construction of merchant vessels. State age, experience (in detail) and salary expected.—Address, VESSELS, Wm. Porteous & Co., Advertising Agents, Glasgow. G 259

Wanted, Commercial

MANAGER having intimate connection with shipowners and shipbuilders. Excellent prospects for right man.—Apply, THE PIRBRIGHT CO., Ltd., Bond Court House, Walbrook, E.C. G 270

Works Manager for Large

Ship Repairing and Engineering Works, South of England, WANTED to take charge of shops and foundry; age 35 to 40 years, must be capable organiser with thorough practical training. Applications will be considered only where age, details of responsible positions already held and salary expected are stated.—Address, G 238, Offices of Engineering.

Young Engineer Wanted

shortly for Contract near London. Must be college-trained and keen.—Address, G 227, Offices of Engineering.

Resident Engineer Wanted,

for supervising erection of ferro-concrete structures including Jetty; experience in similar work essential, including inspections in diving dress.—Address, stating age, experience and salary required, G 239, Offices of Engineering.

Engineer, First Assistant,

WANTED by large manufacturing concern in Scotland. Applicants must have thorough theoretical and practical knowledge of electrical and mechanical engineering. Preference given to University Graduate. Considerable experience in general mechanical designing essential. Permanent situation with good prospects for suitable man.—Address, G 273, Offices of Engineering.

Head Draughtsman

(Structural), sound theoretical and practical experience. Age between 30 and 40.—Salary about £450-600 according to qualifications. Address, stating experience, G 187, Offices of Engineering.

Head Draughtsman with

wide experience in the design and application of all classes of Centrifugal Pumps and High Speed Engines for Marine and Land work; able to control staff efficiently and economically; state age, full details of experience and salary expected.—Address, G 188, Offices of Engineering.

Required, the Services of a

DRAUGHTSMAN experienced in the design, arrangement and detail of Cane Sugar Factory Curing Plant. Only applications from men having expert knowledge of modern practice will be considered.—Address, G 221, Offices of Engineering.

Draughtsman Required for

general plant and constructional work in large engineering works in East Midlands. Applications should state full details of experience, age and salary required.—Address, G 265, Offices of Engineering.

CORPORATION OF LIVERPOOL.

Wanted, in the Land Steward

and Surveyor's Department, THREE FIRST-CLASS DRAUGHTSMEN fully experienced in the design and detailing of Steel Frame Structures.

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ROLL BEARINGS FOR COLD ROLLING MILLS.

By C. E. DAVIES, A.M.I.Mech.E.

(*Continued from page* 571.)

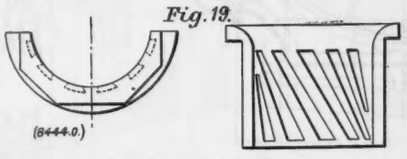
Materials.—Practically all roll bearings for cold rolling mills are made of a bronze alloy, but the quality varies with individual cases. In the cheaper classes of rolling mill, naturally the high cost of expensive alloys is prohibitive, and a gun-metal containing an appreciable quantity of lead, such as 86 per cent. copper, 9 per cent. tin, 3 per cent. zinc, 2 per cent. lead, is frequently adopted, and gives reasonably good service. Where the buyer gives due consideration to wearing qualities and efficiency a high grade gun-metal or phosphor bronze is specified. Admiralty mixture gun-metal with proportions of 88 : 10 : 2, is very generally put in by makers of high-class rolling plant, but recently many have found phosphor bronze to give the best service and the leading makers of rolling mills in this country and on the Continent have standardised the practice in this direction. A good bronze of this class should consist of 89·5 per cent. copper, 10 per cent. tin, and 0·5 per cent. phosphorus. While a true bronze should contain no zinc or lead, many metallurgists would see no objection to 2 per cent. lead in either gun-metal or phosphor bronze, and for bearings 5 per cent. or even 10 per cent. has been recommended. A phosphor bronze adopted by the Pennsylvania Railway Company, is reported to contain 80 per cent. copper, 10 per cent. tin, 9·5 per cent. lead, 0·5 per cent. phosphorus; and another mixture, recommended for heavy marine engine bearings, gives 82·5 per cent. copper, 13 per cent. tin, 4 per cent. lead, and 0·5 per cent. phosphorus. A phosphor bronze containing 83 per cent. copper, 9 per cent. tin, 7·5 per cent. lead, and 0·5 per cent. phosphorus is regularly used. The necessary qualities which a good bearing metal requires for rolls are by no means easy to determine; generally it is considered that a hard metal is desirable, and for this a hard grade of gun-metal or phosphor bronze is favoured.

There is a very considerable divergence of opinion on this, and while some users demand a hard bearing metal, others claim that a softer metal causes less friction and wears better than the harder. Actually, it is necessary to consider both the material of the rolls and the hardness of the necks, and also the method of lubrication, before specifying the nature of the bearing metal. With the ordinary class of mill, fitted with chilled C.I. rolls having grease lubrication and external water cooling of bearings, it is better to use a softer gun-metal than would be recommended for an up-to-date mill with steel rolls and automatic oil lubrication. Any engineer who has examined the necks of rolls which have been worked for any long period in a mill of the older type, will appreciate this point, for in the majority of cases the necks will be found to be deeply scored, showing that the heavy pressure combined with inadequate lubrication has caused the metal of the bearing to cut into the roll necks. Needless to say, such conditions cause excessive frictional losses, and render a copious water supply necessary, if the temperature of the bearings is to be kept within reasonable limits.

Although the conditions requisite for good roll bearings are better understood now than they were a few years ago, there are still many mill users who fail to appreciate the necessity for keeping the surface of the roll neck itself in good condition. A scored bearing is certain proof that metal-to-metal contact between neck and bearing has occurred, if not also the presence of abrasive dust. It is certainly difficult to prevent the emery powder used in scouring rolls, from entering bearings, but from an engineer's point of view it seems folly to expect a bearing to run cool, if such abrasive substances are allowed to reach the bearing surfaces. Further reference will be made to this point is connection with the question of lubrication, but it may now be noted that in all cases the neck of the roll should be appreciably harder than the metal of the bearing in which it is supported, and should be finished truly circular by grinding and with a good surface. Any signs of scoring which may take place should be removed by regrinding when necessary.

The experiments of Lasche and others on bearing friction have shown that the frictional losses are much the same whatever metal is used for either the journal or the bearing, but this conclusion only holds good when reasonably efficient lubrication is obtained. This is almost self-evident, as, given a film of oil separating the bearing surfaces, the nature of the metals employed cannot have much effect on the friction. In the average mill an unbroken film of lubricant cannot be taken for granted, and the metals in contact must be selected with a view to minimise the tendency to seize. In most cases with chilled cast iron or hardened steel rolls, with unhardened necks, a moderately hard gun-metal or phosphor bronze gives perhaps the best results. Softer gun-metals give trouble and wear rapidly owing to the "burring" over at the ends of the bearings, thereby reducing the effective bearing surface. If it were not for this, softer metals such as the many excellent white metal alloys would be preferable, as friction losses would probably be reduced, any inaccuracies in alignment would correct themselves, and certainly the risk of damage to the surface of the roll neck would be reduced. As far as the writer is aware, no trial of entire white metal roll bearings in a cold mill has been attempted in this country, and moreover, an alloy rich enough in tin to give sufficient hardness, would be costly; but the application of white metal, inserted as strips in a shell of harder metal is now very generally adopted for the best class of cold rolling mills. A bearing of this type is shown in Fig. 19.

Fig. 19.



The body is of hard gun-metal or phosphor bronze with strips of high grade anti-friction metal disposed spirally in the bore. In this way sufficient support is provided to prevent the squeezing out of the softer metal, and at the same time the advantages of a white metal bearing are partially secured. Such bearings have been proved to give excellent results under the heaviest loads and are perhaps the best type of bearing in use at the present time. Messrs. W. H. A. Robertson and Co., Limited, of Bedford, who have carried out numerous experiments on roll-bearing friction, have adopted this bearing as a standard for their high-grade mills, especially those operating at high speeds. Another advantage obtained by the use of inserted white metal strips, which is not quite obvious, is that the softer white metal tends to wear down very slightly below the surface of the containing bearing, and provides a minute clearance which is filled with lubricant, thereby ensuring an oil film over a very large portion of the bearing surface. This quality has been proved for heavy machinery bearings of other classes, but has not been appreciated as it deserves in connection with roll bearings. The spiral form of the white metal strips prevents to a very great extent the scoring of the roll neck. Bearings of this class are relatively costly, the total weight of metal is somewhat greater than that for a plain bearing, and the cost per pound is high. In addition, there is extra labour cost incurred in casting and in running in the anti-friction metal.

In the course of the experiments referred to above it was found that the use of expensive metal as a containing shell in such bearings was unnecessary. This led to the trial of a set of "brasses" which were made of a specially good quality cast iron, in which spiral strips of white metal were inserted. These bearings were tested under the heaviest loads with excellent results, and have been since subjected to an endurance test, carrying rolls employed intermittently for both hot and cold rolling work, over a period of many months. The results obtained have surpassed expectations, and so far no disadvantage due to the use of this cheaper bearing metal has come to light. The surface of the cast-iron portion of the bearing surface is excellent, no sign of scoring on the chilled roll necks can be detected, and the bearings keep as cool as, if not cooler, than the ordinary bronze bearings previously fitted to the mill. The saving in cost in a set of bearings of this construction in a medium sized mill, is very considerable, and if, in addition, the running qualities are superior, there would seem to be little necessity to use bronze bearings in future. Cast-iron bearings lined with white metal are, of course, by no means new, having been employed for engine and other bearings for many years, and the property possessed by cast-iron bearings, of taking a high surface polish and becoming intensely hard under the rubbing action of the journal is well known.

(*To be continued.*)

THE TWIN-SCREW GEARED-TURBINE ORIENT LINER "ORAMA."

(*Concluded from page* 544.)

THE general arrangement of the machinery is perhaps best shown in Fig. 10, Plate LVII, page 543, *ante*. From this it will be seen that there are two boiler-rooms in each of which there are three double-ended and two single-ended boilers. The bunkers for the oil fuel line each side of the boiler-rooms, and are extended forward along the sides of the refrigerating machinery rooms.

As already mentioned the Orama will require about 19,500 shaft horse-power to propel her at the designed speed of 20 knots. The ship has accordingly been fitted with single reduction geared turbines, which are supplied with superheated steam by oil-fired boilers having a working pressure of 215 lb. per square inch (gauge). The turbines are of the Parsons type. It was considered desirable that the machinery for each of the twin shafts should be an entirely independent mechanism complete in itself, and hence, the port and starboard sets each comprise a high pressure, an intermediate and a low pressure turbine arranged round the main gear wheel, as is indicated in Fig. 18, Plate LXIII, or perhaps still better in the key plan of the arrangement of turbines and gearing, Fig. 23, page 602. An excellent idea of the general arrangement can also be obtained from Figs. 13 and 14, Plate LXII, and from Figs. 21 and 22, Plate LXIV. Each of the three turbines comprising the set is connected by a flexible coupling to the nickel steel double-helical pinion gearing with the main wheel. The latter has a cast-iron centre on which two rings of mild steel, in which the teeth are cut, are shrunk and keyed. This wheel has a pitch diameter of 156 in., whilst that of each of the nickel steel pinions is a little over 10¼ in. Sections through the gear-box are reproduced in Figs. 24 and 25, page 602, and from these it will be seen that the pinions are supported on three bearings. The double-helical teeth are of the ordinary involute type. They have an effective axial length of 4 ft. 2 in. A section through the claw type flexible coupling, by which the pinion is connected to the turbine shaft, is shown in Fig. 24, from which it will be seen that provision is made for slight axial motion of the pinion. At full speed the turbines run at 1,370 r.p.m. and the propeller at 95 r.p.m., the ratio of reduction is therefore 14·4 to 1.

A longitudinal section through the turbine room is reproduced in Fig. 15, and a plan in Fig. 16 (Plate LXIII). A noticeable feature about the latter is the comparative freedom of the floor space, which is mainly due to the compactness of the turbine drive, since the auxiliary machinery is unusually ample and complete.

A section through the high-pressure turbine is represented in Fig. 26, page 602. It consists, it will be seen, of a two-row velocity compounded wheel, 5-ft. 4-in. mean diameter, followed by four groups of reaction blading, mounted on a drum 2 ft. 9 in. in diameter. The blading ranges in height from 1⅜ in. at the high-pressure end of the turbine to 2⅝ in. in height at the last group. The end thrust on the reaction blading is balanced by a dummy of the usual type, any residual load being taken by a Michell thrust block at the forward end of the casing. Bye-passes are provided into the velocity wheel compartment, and also between the first and second groups of the reaction blading, so that, should the need arise, a very large overload may be taken. The live steam branches are all 8 in. in diameter.

GEARING AND H.P. TURBINE OF THE TWIN-SCREW ORIENT LINER "ORAMA."

CONSTRUCTED BY MESSRS. VICKERS LIMITED, ENGINEERS AND SHIPBUILDERS, BARROW-IN-FURNESS.

Fig. 23. PORT SET

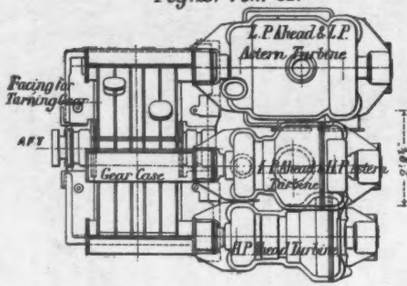


Fig. 24.

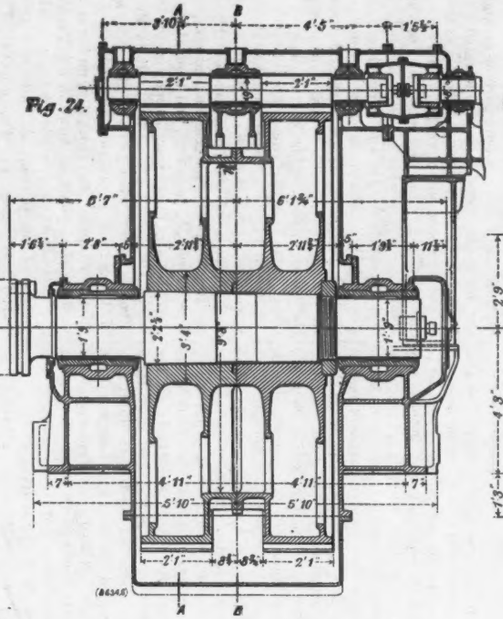


Fig. 25.
HALF SECTION AT A.A. LOOKING FORª

HALF SECTION AT B.B. LOOKING FORª

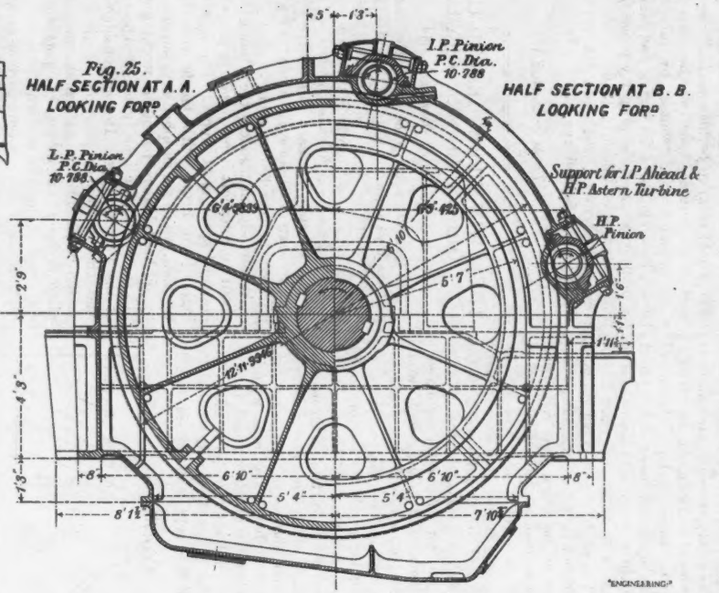
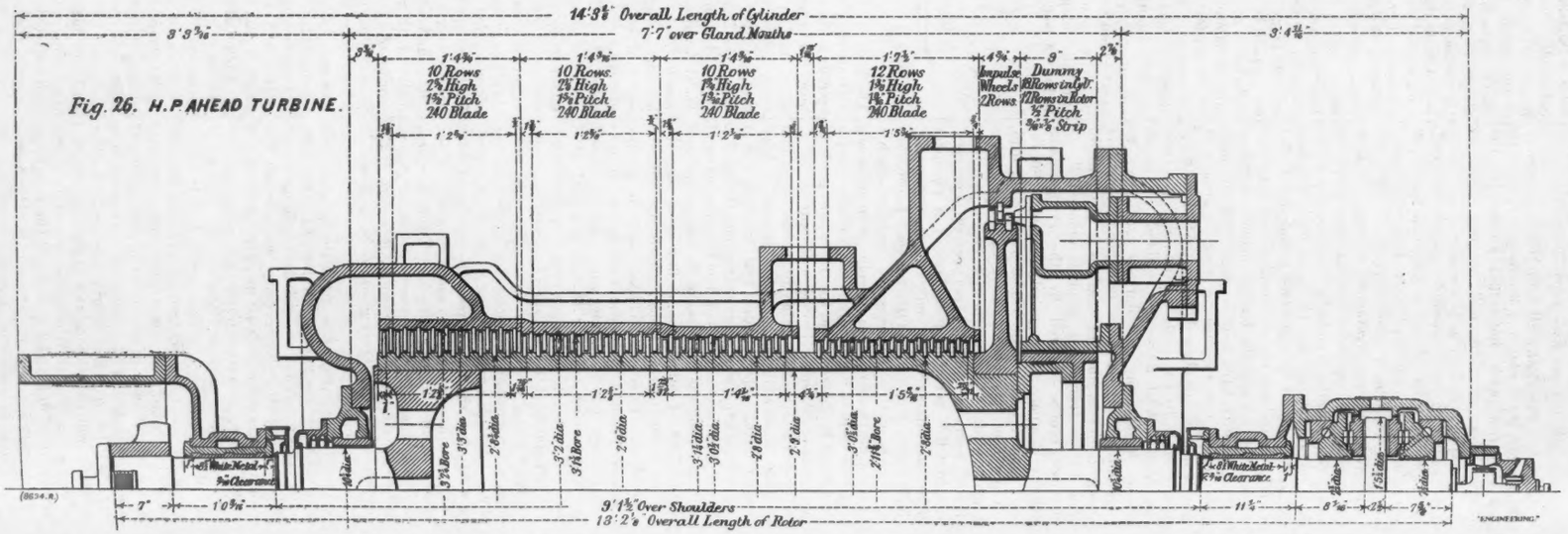


Fig. 26. H.P. AHEAD TURBINE.



I.P. AND L.P. TURBINES OF THE TWIN-SCREW ORIENT LINER "ORAMA."

CONSTRUCTED BY MESSRS. VICKERS LIMITED, ENGINEERS AND SHIPBUILDERS, BARROW-IN-FURNESS.

Fig. 27. I.P. AHEAD TURBINE & H.P ASTERN.

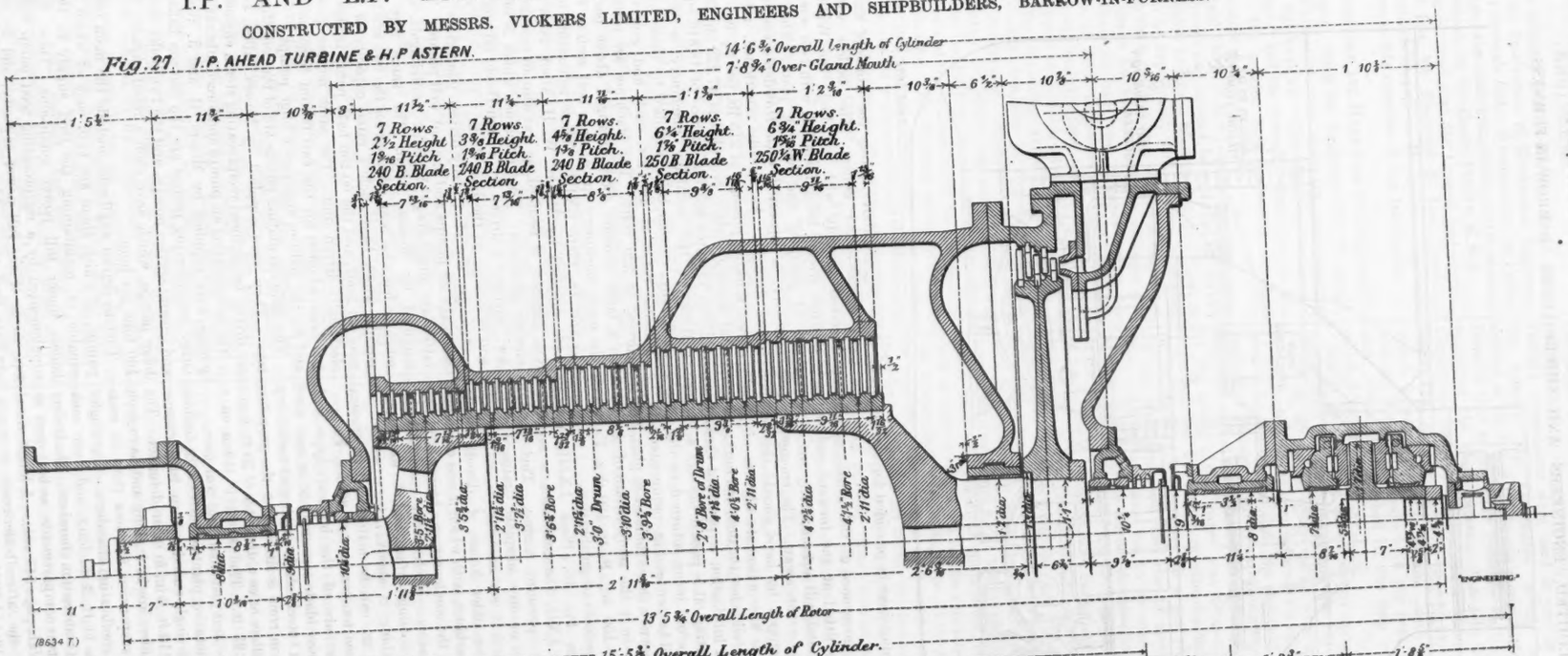
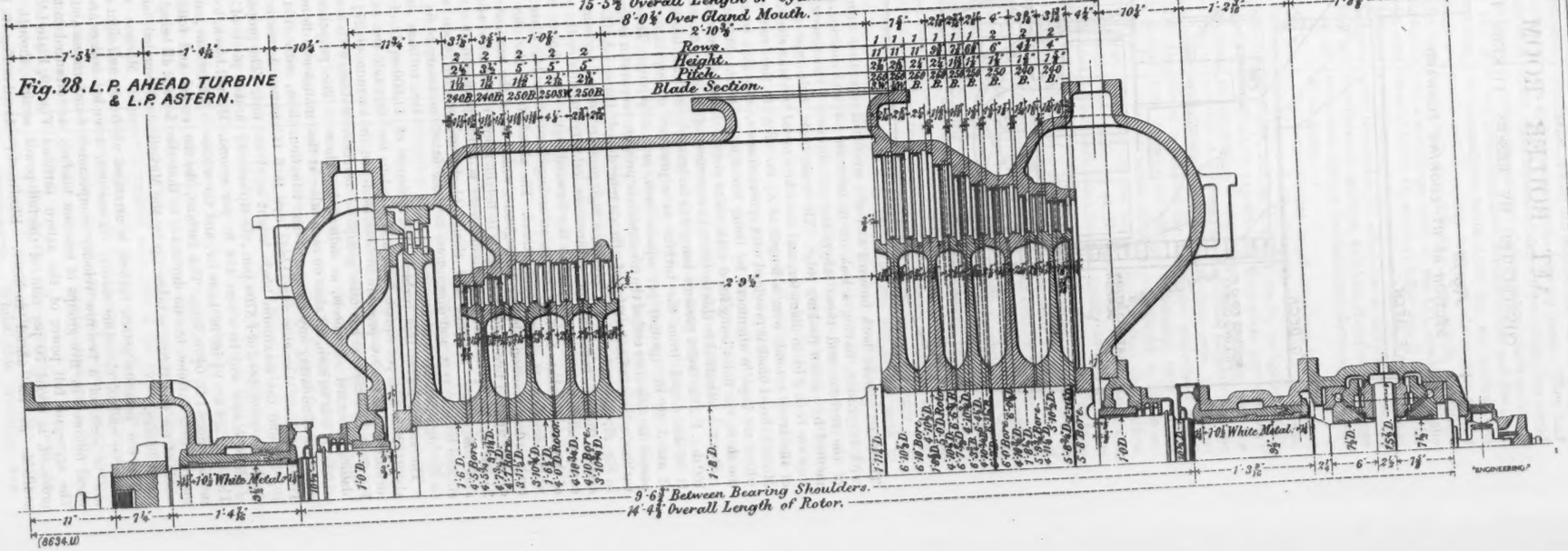
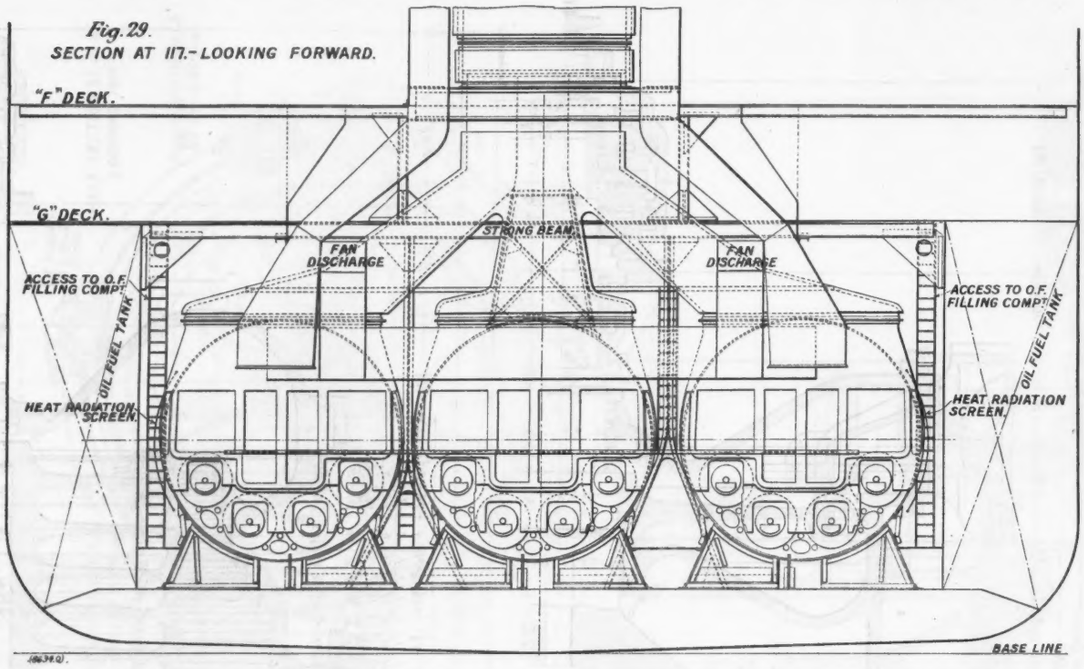

14'6¾" Overall Length of Cylinder
7'8¾" Over Gland Mouth
7 Rows 2½" Height 1⁹/₁₆" Pitch 240 B. Blade Section.
7 Rows 3⅜" Height 1¹³/₁₆" Pitch 240 B Blade Section
7 Rows. 4⅝" Height. 1⅜" Pitch. 240 B Blade Section.
7 Rows. 6¼" Height. 1⅞" Pitch. 250 B Blade Section.
7 Rows. 6¾" Height. 1⁹/₁₆" Pitch. 250½ W. Blade Section.
13'5¾" Overall Length of Rotor
(8634 T.)

Fig. 28. L.P. AHEAD TURBINE & L.P. ASTERN.



AFT BOILER ROOM OF THE ORIENT LINER "ORAMA."

CONSTRUCTED BY MESSRS. VICKERS LIMITED, ENGINEERS AND SHIPBUILDERS, BARROW-IN-FURNESS.



The shaft glands, both forward and aft, are fitted with labyrinths, having a leak off to later stages of the turbine, and these labyrinths are supplemented by carbon packing rings. The main bearings are both 8 in. in diameter, and the white metal of the brass extends over a length of 8½ in. The Michell thrust block is provided with spherical seats, which are kept in alignment by being bored to fit the shaft, the holes being lined with white metal.

Steam is admitted to this turbine at a superheat of 150 deg. F., the boiler pressure being 215 lb. (gauge). It is discharged from the turbine at a pressure of about 40 lb. (gauge) per square inch, and is passed into the after end of the intermediate pressure turbine, a longitudinal section of which is reproduced in Fig. 27, page 603. As will be seen, a high-pressure astern turbine, consisting of a three-row velocity compounded wheel, is provided in the forward end of this intermediate turbine casing, an arrangement which simplifies the steam connections. The ahead turbine has reaction blading throughout, which is divided up into five groups, ranging in height from 2½ in. up to 6¾ in. The drum diameter is 3 ft. and the glands, bearings and thrust blocks are similar both in type and dimensions to those fitted to the high-pressure turbine.

The steam leaves this turbine at a pressure of about 12 lb. abs. per square inch, and is led to the forward end of the low-pressure turbine, as shown, in Fig. 28. This turbine has nine groups of reaction blading mounted on wheels, as indicated. These wheels, it will be seen, all abut on each other at the rim, thus eliminating any danger of disc vibration. The maximum diameter over blade tips is 6 ft. 10⅞ in., and the maximum blade height is 11 in. At the designed speed of 1,370 r.p.m., the tip velocity of these blades will be about 494 ft. per second. The bearings are 9½ in. in diameter, and the white-metal linings 1 ft. 0½ in. long. This turbine, like the intermediate turbine, has no dummies, so that the whole of the end thrust is taken up by the Michell thrust blocks.

The low pressure astern turbine is arranged at the after end of the same casing. It consists, it will be seen, of a two-row velocity compounded wheel followed by five groups of reaction blading. The aggregate full power of the astern turbines provided, is about 70 per cent. of the full power available in the ahead turbines. Electrically-operated turning gear is provided for the turbines and shafting.

Emergency governors of the usual unbalanced bolt type are fitted at the forward end of each turbine shaft, and will automatically cut off steam in the event of a run away. The emergency gear can also be tripped by hand should the occasion arise. Steam is also automatically cut off should the oil pressure fall below the designed limit. As customary, forced lubrication is provided throughout, and the lubricating oil is passed through a Vickcen oil separator before being returned to the supply piping. The oil heater used in conjunction with the separator is shown in the turbine room plan, Fig. 16, Plate LXIII. In it the temperature of the oil is raised to some 150 deg. F. to 180 deg. F., which facilitates the process of purification.

As shown in Fig. 15, Plate LXIII, and in Fig. 14, Plate LXII, the condenser is suspended from the low pressure casing. This position of the condenser ensures adequate drainage of the turbine, for which it was necessary to make special provision in the older forms of direct coupled marine steam turbines, with which it was commonly necessary to fix the condenser at a higher level than the turbine casing. Each main condenser has 11,000 sq. ft. of cooling surface, and the water speed through the tubing is about 7 ft. a second. A vacuum of 27¾ in. can be maintained in tropical waters, with a sea temperature of 86 deg. F.

The propellers are of the built-up type with manganese bronze blades, secured to a cast steel boss, with mild steel studs and gun-metal cap nuts. A cast-iron cone is fitted over the propeller nut. The propellers have a diameter of 20 ft. 6 in., and a pitch of 23 ft. The thrust is taken on a Michell block, located just abaft the gear case.

The steam generating plant consists of six double-ended and four single-ended return tube marine boilers, all being 16 ft. 6 in. in mean diameter. The double-ended boilers are 22 ft. long and have each eight Morison suspension furnaces (four in each front), and eight combustion chambers. The single-ended boilers are 11 ft. 3 in. long, and have each four furnaces and combustion chambers. The boilers are arranged in two compartments, as best seen in Fig. 10, Plate LVII, page 543 *ante*. A longitudinal section through the after boiler-room is reproduced in Fig. 19, Plate LXIII, and a plan in Fig. 20, whilst Fig. 29, above, shows the fronts of three of the double-ended boilers. The boilers will be operated entirely with oil fuel, the Wallsend-Howden system being installed, with two complete sets of pumping and heating plant. They will moreover, be operated with Howden's system of forced draught. As already mentioned, the designed working pressure is 215 lb. per sq. in. The total heating surface provided is 47,222 sq. ft., in addition to super-heating surface of 18,816 sq. ft.

Much of the auxiliary machinery is driven electrically, current being supplied by three turbo-dynamos rated at 400 kw. each and generating current at 220 volts. The machines are installed in a large dynamo room arranged above part of the main machinery space, as is best seen in Figs. 15 and 18, Plate LXIII. These generating units were supplied by Messrs. W. H. Allen, Sons and Co., Limited, of Bedford, as was also an emergency electric generator. This machine, which is of 50 kw. capacity is driven by a semi-Diesel oil engine, and is located on the boat deck.

Amongst the electrically-driven generators are the main air pumps and the hot well pumps. The latter are single-stage high-lift centrifugals, also supplied by Messrs. Allen. The same type of machine has also been adopted for the two sanitary pumps, which have each a rated capacity of 200 tons per hour, and the 60-ton bath pump is also an electrically-driven unit. The same motive power has been adopted for the two 60-ton bilge pumps and for the 160-ton emergency bilge pumps.

The main circulating pumps are of the centrifugal type. They were supplied by Messrs. Allen, and are driven by enclosed reciprocating steam engines.

The reciprocating air pumps and forced lubrication pumps were supplied by Messrs. G. and J. Weir. Other reciprocating pumps are the 250-ton ballast and general service pumps, and the two boiler room bilge pumps, which have each a rated capacity of 160 tons per hour.

Turbine-driven auxiliaries include the main feed pumps, of which there are two, each of which is capable of maintaining the feed supply to the boilers under full power conditions. These are supplemented by a reciprocating feed pump with two-thirds of the full power capacity, and by an auxiliary feed pump which is provided for use in harbour.

THE INSTITUTION OF MECHANICAL ENGINEERS.

The first ordinary general meeting of the winter session of the Institution of Mechanical Engineers was held at Storey's Gate, Westminster, on Friday last, at 6 p.m., the chair being taken, in the absence of the President, by Sir Henry Fowler, K.B.E.

It was announced that the Council had elected, on July 11 last, Mr. Frederick R. Low, President of the American Society of Mechanical Engineers, as an honorary life member of the Institution.

Missing Pressure and Heat Loss in Gas Engines.

Two papers, both by Professor W. T. David, of Leeds University, were down for consideration. The first was entitled "The Missing Pressure in Gas Engines" and the second "Heat Loss in Gas Engines." We reprint both papers in abridged form in another part of this issue.

Sir Dugald Clerk, F.R.S., opened the discussion. Speaking on the first subject, he said that the matter was one which had long been in doubt. When he first began to experiment with gaseous explosions he came to the conclusion that several of the things, which Professor David had since proved, were probable. When he had read a paper before the Institution of Civil Engineers in 1886,* his conclusions were, mainly, that combustion was very similar to other chemical reactions, the first part of the reaction occurring rapidly, but proceeding with increasing difficulty as the combustion approached completion. Moreover, he had stated that the explosion space was entirely filled with flame before combustion was complete; the spread of the flame and the combustion of the gas were distinct phenomena. The limiting causes acted after the flame had spread completely. The limiting cause in the case of weak mixtures, of the diminution in the rate of burning as the reaction approached completion, was the rate of cooling. His apparatus was not so delicate as that of Professor David. His curves with different mixtures, like those of Professor David, showed, first, a relatively slow rise of pressure as the flame spread. This increased until the rate was very fast. As the curve approached maximum pressure there was sometimes a little break and a bend over, followed by the cooling curve. At the break he used to say that the flame had spread throughout the whole mixture, but, of course, that was only inference. He had had no doubt that the pressure continued to rise after the flame had completely spread through the vessel, but few people would accept that opinion from him 38 years ago.

In the case of the internal-combustion engine, a similar thing happened. At the beginning of the stroke one had a slowly moving piston. Afterwards the piston would move more rapidly, and the rate of combustion was being reduced although the temperature was actually increasing. Then for a short distance the diagram showed almost an isothermal curve, the line gradually altering as one went slowly down the curve. From the foregoing, he had inferred what Professor David had now proved. He had been unable to accept the idea of the change in specific heat until some years later than 1886. One inference he had made by comparing actual brake experiments with indicator diagrams and load consumptions. This was that, by taking the air standard cycle for a certain mixture, without any attempt to allow for varying specific heat, &c., and by multiplying the efficiency given by the air standard cycle by 0·7, he obtained a number which at once gave the actual efficiency. Many people found fault with the standard air cycle, because, they said, it did not deal with the real working fluid. He could understand that, but it seemed to him a feasible method to fix a standard of some kind which was invariable for all conditions, and then multiply this by a coefficient which would give something closely approaching reality. Professor David's work showed that the theory of the internal-combustion engine could not be based only on the variation of specific heat. It might be said that the puzzle of the heat losses and the shortage of pressure had at last been finally solved.

* Proc. Inst. C. E., vol. lxxxv, page 1.

The radiation experiments, Sir D. Clerk continued, were very surprising. The British Association Committee on Gaseous Explosions had dealt with radiation and, in that connection, some of Professor David's experiments were used in one or two of the reports. The Committee never, however, arrived at the law of the fourth power, although he believed that at one time Professor Callendar had suggested the third power. The late Professor Hopkinson had made experiments which showed clearly that by the use of a very highly polished vessel, it was possible to obtain, with the same mixture, a rise in pressure of 4 per cent. to 5 per cent. above that reached in the case of an unpolished vessel.

Mr. D. R. Pye said his criticisms upon the two papers were not directed against the experimental skill with which the observations were made but rather against the superstructure built upon them—greater in his opinion than the observations were capable of bearing. All the experiments referred to had been carried out before 1910. The main object of the author's first paper was to establish the importance of his theory of after-burning as one of the causes of lost pressure in a gas engine, side by side with heat loss and rise of specific heat. That after-burning was not to be confused with dissociation which the author definitely repudiated in his paper. The difference between the two was, of course, that in what was spoken of as after-burning the author considered there was not chemical equilibrium until combustion was complete (the phenomena was a pure time effect)—whereas if dissociation occurred it meant that while combustion was incomplete round about the maximum pressure point there was chemical equilibrium, but all the heat of combustion could not be generated because the temperature was too high for all the CO and O_2 to combine; they had to wait until the temperature had dropped a bit before the last of the heat could be developed. In some conditions no doubt the continued burning after maximum pressure would be considerable; with weak mixtures, at low initial pressures and under stagnant conditions (as in closed vessel experiments) combustion took quite a long time to occur, but it was a mistake to speak of after-burning as a cause of lost pressure side by side with heat loss and rise of specific heat, and all calculations about after-burning were of doubtful value, because its amount in any engine depended on the particular conditions of running and within limits it was readily controllable. It was dependent in the first place on mixture strength, and in the second upon two factors which were scarcely mentioned in the paper but which were of paramount importance, namely, ignition advance and turbulence in the cylinder.

All the author's figures for the proportion of unburnt charge at the instant of maximum pressure were dependent on curves which were derived, he understood, from measurements of the rise of temperature of a polished silver grid on the inner surface of the vessel, with allowance for the heat which passed through to the backing behind. The author's silver grid was at most 2·5 per cent. of the internal surface of the calorimeter, and from measurements of the heat received by this small surface, placed in an arbitrary position inside an unsymmetrical vessel, the whole heat received by the remaining 97·5 per cent. of surface was calculated, although the author admitted that the heat lost by conduction was not uniformly distributed over the interior surface of the vessel. The rate of transfer depended very much on the exact nature and condition of the metal surface and the speed of the gas past it. It was difficult to believe that the silver-plated cast-iron surface would be identical with the polished silver grid; while convection currents would certainly vary over different parts of a cylindrical vessel. The figures for total heat loss must, therefore, be accepted with the greatest reserve.

Even if it were possible to make a reliable estimate of the amount of unburnt gas at the moment of maximum pressure in any one set of conditions, such figures were relatively unimportant because they would not depend on any fundamental property of the gases involved, but on special conditions which were readily controllable. After-burning, which was a time effect, differed completely from dissociation, which did depend only on the temperature and pressure of the burning gases. They had direct experimental evidence from which they could calculate the amount of dissociation which occurred in any given conditions of temperature and pressure. At temperatures below 2,000 deg. the amount was small, and it rapidly increased above that point; for example, at 2,500 deg. C. and 400 lb. per square inch about 10 per cent. of the CO_2 would be in the form of CO + O, while at 2,700 deg. C. and 600 lb. per square inch about 30 per cent. would be. It was quite impossible to affect those figures by special conditions of ignition, &c., and therefore they were dependent only on fundamental chemical properties of the gases.

He believed that in all but high-speed engines the amount of after-burning, as distinct from dissociation, was, or could be made, negligibly small. Hopkinson's experiments themselves provided very strong evidence that there was nothing like the amount of unburnt fuel the author suggested at the peak of the diagram, or, if there were, that in so far as it reduced the maximum pressure it was a true dissociation effect. Hopkinson took further diagrams under identical conditions to those referred to by the author, except that the ignition was advanced at 15 deg. before dead centre, *i.e.*, an advance three times as great; and, to quote his words, "the diagram is hardly distinguishable from the normal diagram with the same gas charge, the difference of area being less than 2 per cent." If there were really only 70 per cent. of the fuel burnt at the peak in the normal diagram, it was difficult to believe that a more complete combustion would not have been obtained at the diagram peak when three times as long was allowed before the dead centre, unless a condition of chemical equilibrium had been reached in both cases owing to the high temperature. Still more conclusive evidence that there was very little unburnt gas at the peak in Hopkinson's experiments had resulted from some work recently done at Cambridge on a high-speed engine. Very possibly combustion was not complete at the peak of these later diagrams, one of which he showed on the screen, but he doubted if it were very far off; and since in Hopkinson's experiment the compression pressure was higher and the pressure at ignition much higher, and also the time was three times as long, he considered the evidence was strongly in favour of the charge having had time in Hopkinson's experiment to burn completely.

The last point, which he had no time to enlarge upon, was the effect of turbulence, a word which was not once mentioned, he thought, in either of the papers, although all who had worked with high-speed engines would agree that it had an all important effect on the time of inflammation and complete combustion, as well as upon heat loss.

Mr. H. M. Martin spoke next. He said that Professor David had described a very ingenious series of experiments, and had clearly established that delayed combustion might be a very material factor in reducing the pressure attained in gaseous explosions. On the other hand, from purely physical considerations, the speaker doubted whether dissociation was as unimportant as the author held it to be. Mr. Martin saw very considerable difficulties in distinguishing experimentally between "delayed combustion" and dissociation, and he thought that both phenomena were involved in, and interconnected with, each other. Mr. Pye had remarked that, knowing the temperature, the amount of dissociation could be deduced from known data, but this held good only if the radiation traversing the gas was "black body" radiation. As far back as the 'eighties of last century Sir J. J. Thomson arrived at the conclusion that gaseous dissociation was not due to molecular collisions, but to radiation, and some four or five years ago Professor Perrin arrived independently at the same opinion. When combustion occurred the radiation quanta emitted were just of the type to promote dissociation of the products formed, and the speaker therefore thought that in every flame there must be both active combination and active dissociation, so that the net rate of combination was a differential effect.

He gathered that the temperatures used in plotting Fig. 5 were deduced from the pressure measurements. Whilst this procedure was

thoroughly sound once chemical combination was complete, it was by no means clear that it was equally legitimate whilst combustion was in progress. The average temperature of a gas was measured by the average kinetic energy of its molecules, but the pressure depended also on the number of molecules present. It seemed probable that the process of combustion must involve temporary associations of the combining molecules, enduring for periods which were not small in comparison with the interval between molecular collisions. This interval was very small, since at normal pressure and temperature each molecule of air made over 1,000 million collisions per second, and the number was correspondingly increased at gas-engine temperatures. Each such temporary association, whilst it lasted, counted but as a single molecule, so that during the period of combustion there might be fewer molecules effective for producing pressure than after chemical equilibrium had been established. It would therefore be well to confirm in some way the temperatures Professor David had assigned to his maximum pressures. In the second paper Professor David had stated that from Planck's equation he would have expected the radiation loss to have been more or less proportional to the square of the absolute temperature, whereas his experiments indicated that it was proportional to the fourth power. Presumably the equation referred to was Planck's formula for the intensity of particular wave lengths in black-body radiation. In the author's experiments, however, the radiation was highly selective, and the speaker thought that there was a difficulty in assigning to this selective radiation an appropriate absolute temperature.

Mr. W. A. Tookey, who followed, said that what he felt was of primary importance was to see how the author's paper corresponded with practice. Referring to Fig. 5 of the author's paper on "Missing Pressure," it was seen that, roughly, the number of centigrade heat units contained in a standard cubic foot of his 15 per cent. mixture was about 50; of his medium mixture, about 40; and of the weakest mixture about 32. As a matter of fact, the mixtures used in gas-engines were rarely more than about 20 C. heat units per standard cubic ft. The diagram showed that as the mixture strength fell so the distance between the maximum points and the corresponding value of a stronger mixture at the same temperature, diminished. With a 20 C.Th.U. mixture the difference thus became probably almost negligible. For those unaccustomed to thinking in C.Th.U. per standard cubic foot, he might say that the figure would be something in the order of 30-40 B.Th.U. It was possible to plot on a horizontal basis the strength of the mixture expressed in so many B.Th.U. per cubic foot against mean explosion pressures on a vertical scale, when the fundamental thermal efficiency—not the thermal efficiency obtained from the engine—could be obtained. If tests made by the professors were plotted in that way, it would be found, as Professor David had said, that with the weakening of the mixture there was less efficiency. But over the range of from 20 to 50 B.Th.U. per cubic foot, the factors on the basis indicated would be very nearly constant, and showed on the diagram only a slightly curved line.

Professor David, in his closed cylinder experiments, had been dealing with a cylindrical capacity full of air. In a gas engine there was the volume swept by the piston of the engine plus the compression space beyond. This compression space was more or less filled with a mixture of air and residuals of combustion, not at room temperature, but at a temperature depending on many things—the speed of the engine, the timing of the spark, &c. The spark itself would vary in intensity with the speed of the engine. He felt that the foregoing combination of conditions—temperature conditions, speed variation conditions, and the conditions in the normal combustion spaces—explained probably why the results obtained by Professor David were very similar to those found in practice with mixtures of quite a different strength.

Mr. W. J. Still remarked that he had considered the problem from a different point of view from the author, having himself attacked it from the standpoint of the actually recorded rate of heat flow in tests of different engines. There was no doubt a great difference between tests in a fixed chamber such as was used by Professor David and the conditions under which an engine operated with a moving piston. He certainly agreed that turbulence accounted for some of the difference shown between such experiments and those found under actual working conditions. Working from trial records of running engines, he had calculated what the heat flow would be for different sizes of cylinders when running at one speed and at one mean pressure. This involved the use of some means of translating the actual results obtained on trials from a lower mean pressure or a higher mean pressure to the mean pressure used as a basis for the particular comparison. The same thing had to be done with respect to the speed of the engine. The smaller engines usually ran at a higher speed and a higher mean pressure than the larger, and it was necessary to equate one up or the other down.

Mr. Still then proceeded to indicate, by the aid of diagrams, the kind of results at which he had arrived. His first diagram gave a number of results obtained from different trials for the heat loss of different gas engines with cylinders varying from 8 in. to 50 in. Drawing a fair line through the points would give something in the nature of a straight line, showing a very much more rapid increase in rate of heat flow per square foot than that suggested by the author. The first diagram was drawn for 70 lb. pressure and 120 r.p.m. A second diagram was drawn for 90 lb. pressure and 200 r.p.m. The curve was similar in character and seemed to justify the equations used in bringing the engines to a common r.p.m. basis. Other curves were shown for tests of four and two stroke oil engines. In this case the line departed from the straight, showing a distinct curve. On the whole the results fell in generally more or less with straight line diagrams.

Professor E. G. Coker, F.R.S., said that some years ago the members of the Gaseous Explosions Committee were of opinion that the missing pressure was due to the three causes which were set out in the author's paper, but he thought they had never reached the degree of completeness with which the author had been able to say how that loss was divided. Apparently from the author's results one might perhaps say that for the first half of the expansion curve the loss due to variable specific heat was roughly equal to the losses due to incomplete combustion and to the cylinder walls, while in the second half the latter loss was much greater. Probably that increase was mainly due to the decreasing value of the specific heat of the burnt gases with the lowering of the temperature. He would like to know the average value of a number of the experiments of the same type. Presumably his examples were typical of a large number of experiments. It would therefore be of interest to know what was the deviation from the mean values given in the paper on which his results were based. Putting that in another way, what was the experimental deviation from the mean values as percentages for, say, the internal thermal energy, the available chemical energy, and the loss due to incomplete combustion at the various temperatures or other points described in the paper?

In the second paper, Fig. 6, represented data on rates of heat loss, which appeared to be consistent or very nearly so, in that the rates were always greater for the weaker mixtures, except perhaps at the low-temperature end; but the author gave little explanation of their meaning, and possibly many would be glad to learn what he considered to be their precise significance. The radiation experiments described with reference to Figs. 7 and 8 were very ingenious, and in that connection he would like to ask a question. If the diagram, Fig. 8, was to scale, how was the ratio $\frac{M_2 M}{M P}$ which gave $\frac{5}{4}$, found?

An important conclusion was that a virtual increase of the lateral dimensions caused by the polished sides made the gaseous mixture more transparent for radiation. It was difficult, however, to picture the molecular mechanism which produced that effect. He hoped the author would give them a brief explanation of the physical causes which produced the result, and, further, of how it was that the vibratory energy of the molecules depended so much on the volume.

Professor A. Smithells, who declined the invitation to speak at any length, remarked that the chemical side of the question was both extraordinarily interesting and extraordinarily difficult. He did not consider that, for the engineering chemist, there was any more important question than that of elucidating the central features of the phenomenon of combustion.

Professor W. A. Bone, said that he did not regard the evidence put forward with regard to delayed combustion as conclusive. To the chemist it was not probable that evidence on the matter of combustion could be satisfactorily obtained from explosions of such a mixture as coal-gas and air. He believed he had proof from experiments that combustion was, in a great number of instances, complete at the point of attainment of maximum pressure. The subject was, however, too large to discuss at such a meeting. There was an alternative explanation which would account for the results, and one which was more likely to be correct than that put forward; it was that at the moment of maximum pressure the gas might not be in true thermal equilibrium, as a result of an abnormal distribution of its energy between vibrational, rotational and translatory energies. Chemists knew that the question could only be properly studied in the case of single gases and when pains were taken to purify those gases when using them.

Professor W. T. David confined his oral reply to a point raised by Mr. Pye, who, he said, was interested in the dissociation theory. He (Professor David) thought that the argument could be disposed of by pointing out that Mr. Pye had accepted the experiments of the German physicists, which showed—as Mr. Pye had specifically pointed out—that there was very little dissociation at temperatures below 2,000 deg. In spite of this, Mr. Pye had asked him to explain the figure of 30 per cent. which he had given for Hopkinson's diagram, in terms of dissociation, although the maximum temperature in the Hopkinson experiment was exactly 1,980 deg.

The Chairman then announced that an informal meeting would be held at the Institution to-night at 7 p.m., when there would be a discussion on "Engineering Novelties at the British Empire Exhibition." The Thomas Hawksley lecture would be delivered on November 7 at 6 p.m. by Vice-Admiral Sir George G. Goodwin, K.C.B., the subject being "The Trend of Development of Marine Propelling Machinery."

THE MOTOR EXHIBITION AT OLYMPIA.

(*Concluded from page* 579.)

In this, our concluding article on the Motor Exhibition, which terminated last Saturday, we deal with a further selection from the mass of cars which were on view. It is impossible for us or anyone else to deal fully from a technical standpoint with all the exhibits, and these articles have covered only a rigidly eclectic selection. We have given a considerable amount of space to the show, but there still remain a number of interesting vehicles which we wish to describe and illustrate. Some of these we hope to deal with in self-contained articles in the course of the next few weeks.

The Lanchester Motor Company, Limited, were one of the pioneer firms in the industry, and no other firm has contributed to a greater extent to the development of modern design. Their products have always been distinguished by originality, and at the present time they are the only firm who utilise epicyclic transmission on a high-powered vehicle. They are exhibiting examples of both their 40 h.p. and their 20 h.p. models. The latter is of recent introduction, and was shown at the exhibition for the first time last year. It is generally very similar to the larger model, the chief difference being that it is equipped with a conventional gear-box in place of one of the epicyclic type. That this is not due to any defect in the epicyclic gear is shown by the fact that the latter is still used on the 40 h.p. car, the reason for the 20 h.p. model being fitted with the conventional box being that four

speeds were decided on for this car, and in such an event the epicyclic gear becomes exceedingly complicated.

The 40 h.p. model has been standardised for some considerable time, and the only change of any importance that has been made recently is the provision of front-wheel brakes. These have been fitted on the smaller model since its introduction, but are a new feature on the 40 h.p. car. Disc wheels are to be standardised with the four-wheel brakes. We illustrated this car in our review of the 1919 Exhibition, and the engine and rear axle have not been substantially altered since that date, and may be seen in section in Plate XXXIV of our issue of November 14, 1919. In Figs. 39 and 40 above, and 44 to 52 on pages 608 and 609, we illustrate the 40 h.p. chassis, with details of the front- and rear-wheel brakes, and of the epicyclic gear. The engine is a six-cylinder model, 4-in. bore by 5-in. stroke, giving a Treasury rating of 38·4 h.p. The valves which are slightly inclined, are operated by an overhead camshaft, the latter being driven by worm and worm wheel through a vertical shaft situated at the forward end of the engine. The crankshaft is of the seven-bearing type, lubrication being by pressure feed throughout. The valves are operated through the medium of rocker arms, and the valves may be removed without disturbing the cylinder block. The engine was fully described in the earlier article published in November, 1919, to which reference may be made for further details. The gear-box we illustrate in Figs. 48 to 52, page 609. It contains three forward speeds and a reverse, the top gear being direct and the other three epicyclic. On reference to Fig. 48, it will be observed that a single-plate clutch is enclosed within the flywheel. This plate slides on the splined head of the transmission shaft, and is enclosed between two fibre-faced discs coupled to the flywheel. Engagement is effected by means of a forked lever acting on a ball thrust bearing, which in turn acts on plungers passing through the flywheel cover disc. Of the three drums shown in the drawing, that nearest to the flywheel is the reverse gear, the middle drum operates the first gear, and the drum remote from the flywheel is the second gear. The gears are brought into operation in the usual way by locking one or other of the drums, the mechanism for effecting this being shown in Figs. 49, 50 and 52. One of the clutches is shown in the latter. Each clutch is operated by a lever engaging with one of the selector bars which are housed on the upper side of the gear casing. Wear on the clutch blocks which hold the drums stationary can be taken up by screwing up the castle nuts situated on the off side of the gear-box. These nuts can be plainly seen in Figs. 50 and 52. It is difficult to explain the operation of the gears in any detail without the aid of diagrams, and for full information on this point we would refer our readers to a paper read upon the subject before the Institution of Mechanical Engineers, by Dr. F. W. Lanchester and Mr. G. H. Lanchester, in April, 1923.

The gear-box forms a unit construction with the engine, this practice, which is now generally favoured, being introduced by Messrs. Lanchester in 1904. The transmission brake is of the internal-expanding type, the method of mounting being clearly seen in the general section of the gear-box

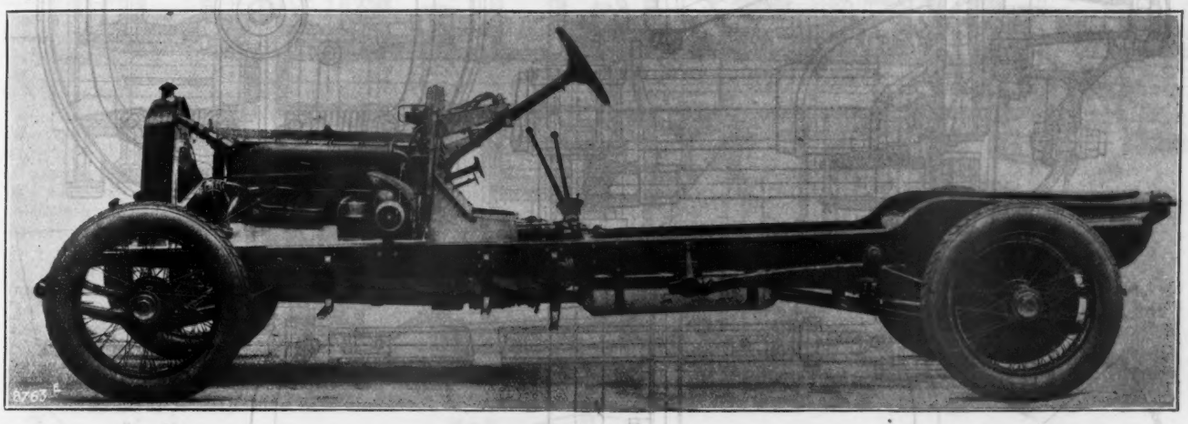


FIG. 39. CHASSIS OF 40-H.P. LANCHESTER CAR.

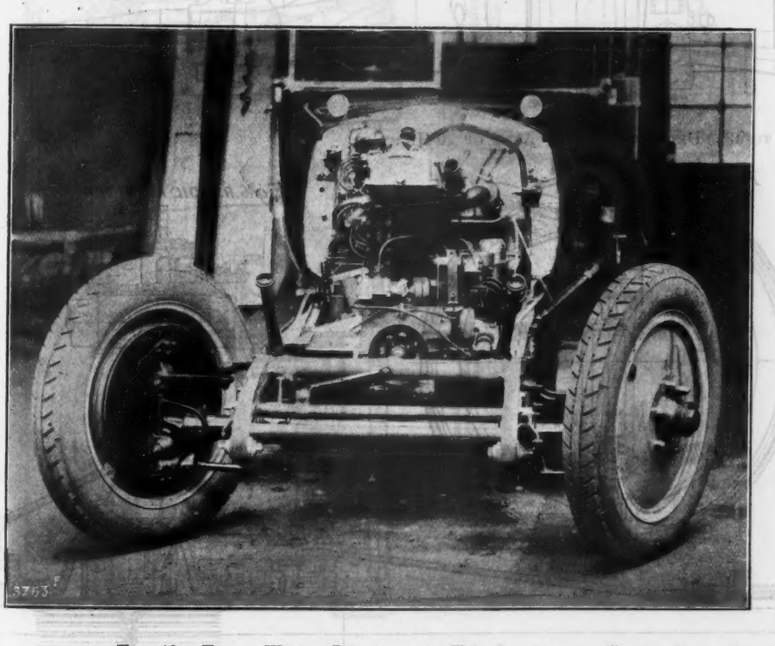


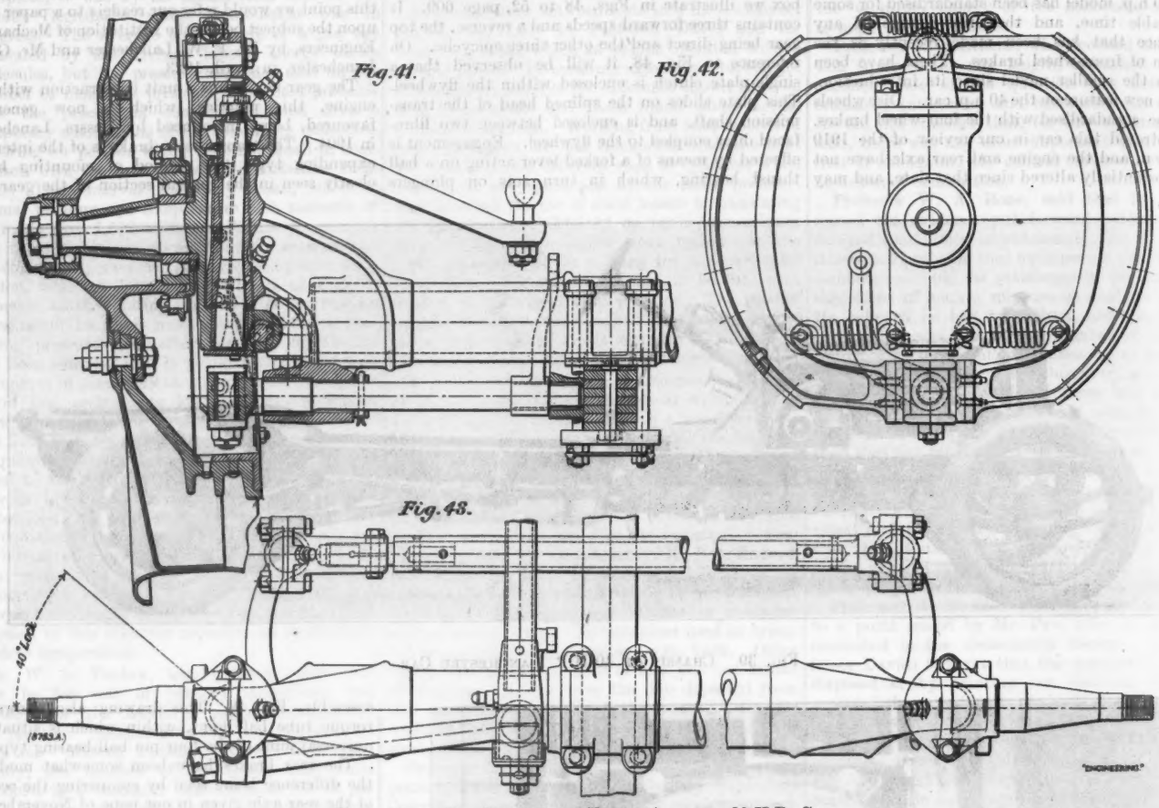
FIG. 40. FRONT WHEEL BRAKE OF 40-H.P. LANCHESTER CAR.

assembly, Fig. 48. This drawing also shows the torque tube ball joint, within which is situated a universal joint of the four-pin ball-bearing type.

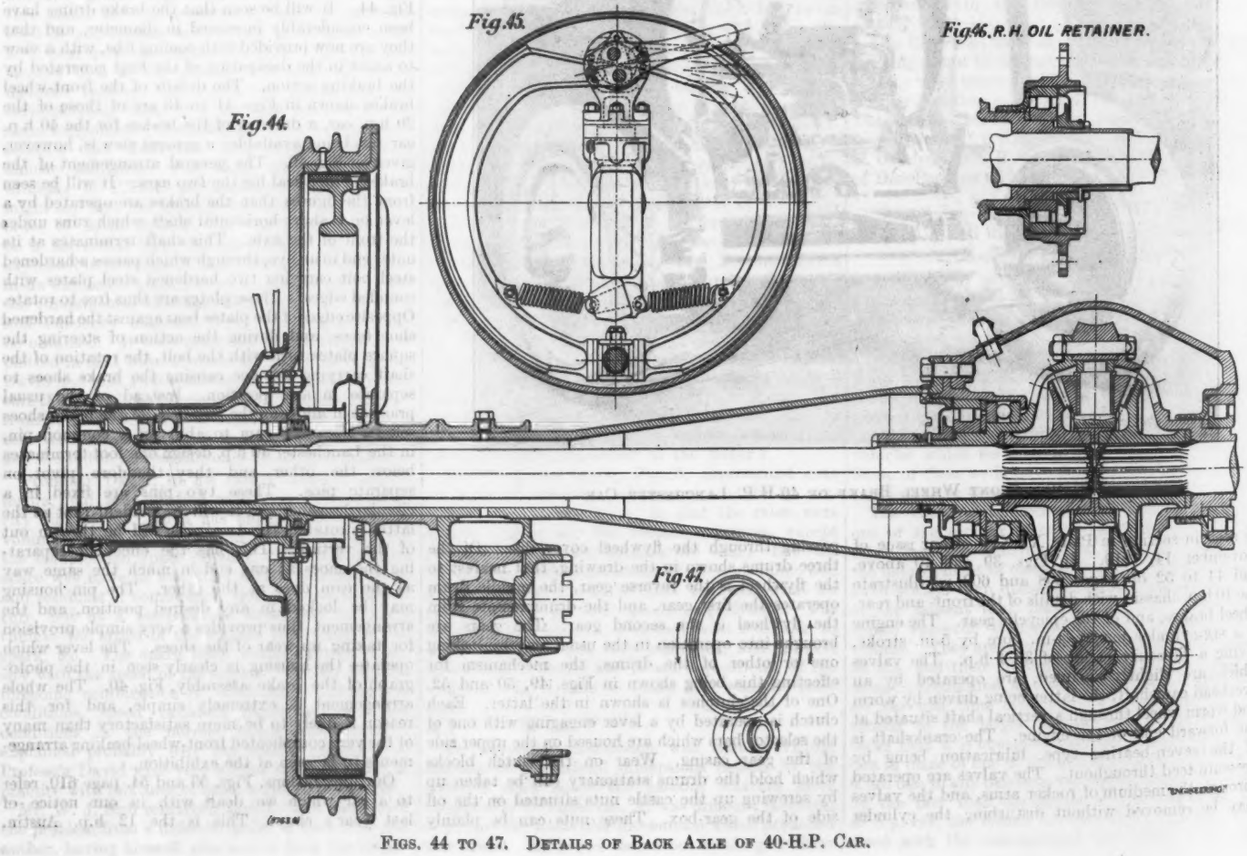
The rear brakes have been somewhat modified, the difference being seen by comparing the section of the rear axle given in our issue of November 14, 1919, with the corresponding section shown in Fig. 44. It will be seen that the brake drums have been considerably increased in diameter, and that they are now provided with cooling ribs, with a view to assist in the dissipation of the heat generated by the braking action. The details of the front-wheel brakes shown in Figs. 41 to 43 are of those of the 20 h.p. car, a drawing of the brakes for the 40 h.p. car not being available; a general view is, however, given in Fig. 40. The general arrangement of the brakes is identical for the two cars. It will be seen from the figures that the brakes are operated by a lever on a short horizontal shaft which runs under the front of the axle. This shaft terminates at its outer end in an eye, through which passes a hardened steel bolt carrying two hardened steel plates with rounded edges. These plates are thus free to rotate. Opposite edges of the plates bear against the hardened shoe faces, and during the action of steering the square plates turn with the bolt, the rotation of the shaft carrying the eye causing the brake shoes to separate in any position. Instead of the usual practice of allowing the two ends of the brake shoes remote from the cam to abut on a common pin, in the Lanchester 40 h.p. design one foot terminates below the other and they therefore pivot on separate pins. These two pins are fixed in a circular housing, and it will be evident that as the latter is rotated the two pins will be thrown out of the vertical. This has the effect of separating the shoes at one end in much the same way as the cam does at the other. The pin housing may be locked in any desired position, and the arrangement thus provides a very simple provision for taking up wear of the shoes. The lever which operates the housing is clearly seen in the photograph of the brake assembly, Fig. 40. The whole arrangement is extremely simple, and for this reason is likely to be more satisfactory than many of the very complicated front-wheel braking arrangements to be seen at the exhibition.

Our illustrations, Figs. 53 and 54, page 610, refer to a car which we dealt with in our notice of last year's show. This is the 12 h.p. Austin,

DETAILS OF 20-H.P. AND 40-H.P. LANCHESTER MOTOR CARS.



FIGS. 41 TO 43. DETAILS OF FRONT AXLE OF 20-H.P. CAR.



FIGS. 44 TO 47. DETAILS OF BACK AXLE OF 40-H.P. CAR.

DETAILS OF 40-H.P. LANCHESTER MOTOR CAR.

Fig. 48.

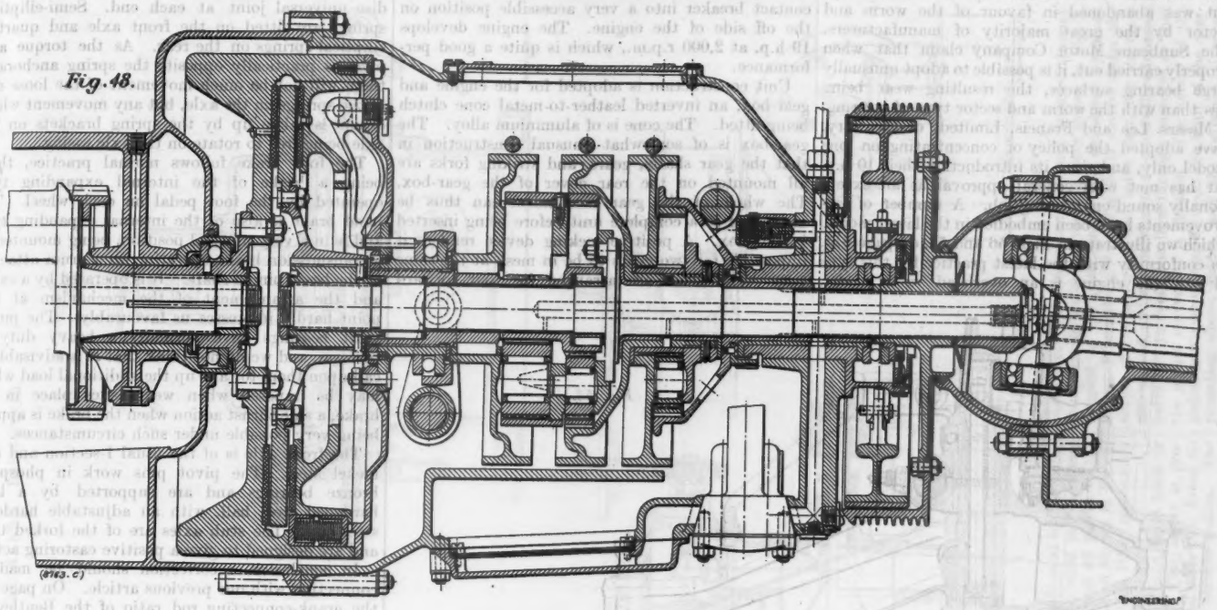


Fig. 49.

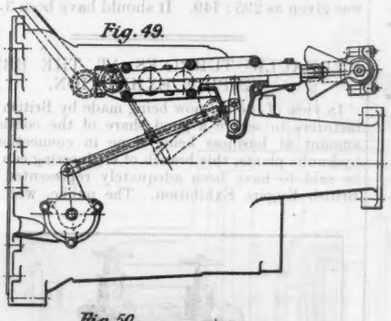


Fig. 51.

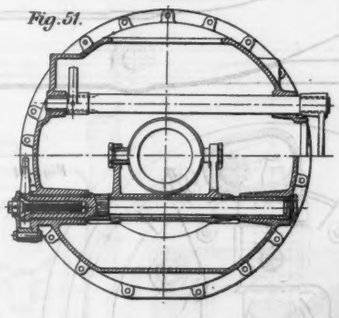


Fig. 50.

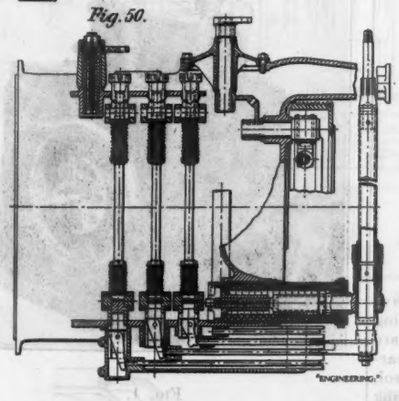
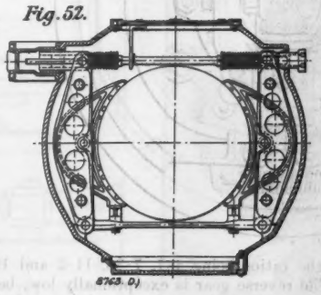


Fig. 52.



made by the Austin Motor Co., Limited, of Birmingham. This car, in common with all the firm's models, is now fitted with front-wheel brakes, and the details of this new feature are shown in these figures. It will be seen from these drawings that the design is neat and simple. The first essential of a front-wheel brake is that it must be capable of operation equally well in any position of the wheels, and that it in no way affects the steering. In the Austin cars this is dealt with by arranging that when the brake pedal is applied, the pull is transmitted through the compensator beam and connections to a lever carried in a bearing at the head of the swivel pin. This lever is clearly shown in Fig. 53. Directly attached to this lever shaft is a second smaller lever, which presses down a rod passing through the centre of the swivel pin. At the bottom of the rod is a wedge which forces apart the brake shoes, expanding them on to the drum, the shoes being normally held off by a spring. To adjust the brakes for taking up wear, it is only necessary to turn the finger nut on the pedal rod. If for any reason it is necessary to set the brakes separately, the intermediate pull rods may be screwed in or out of their respective jaws, a lock nut being provided to hold them when adjusted.

Of our remaining illustrations, Fig. 55, on page 614, refers to the exhibit of the Sunbeam Motor Car Company, Limited. This firm first entered the industry twenty-five years ago, and they early acquired an exceedingly high reputation for refined cars of moderate engine dimensions, but having an exceptional reserve of power when required. They are now marketing three models having engines of 12/30, 14/40 and 20/60 h.p., the first two having a four-cylinder and the latter a six-cylinder engine. The 12/30, which was not on exhibition at the Show, is similar in general design to the 14/40, but is not fitted with front-wheel brakes.

We illustrate the 14/40 h.p. chassis in Fig. 55, from which it will be seen that the frame is exceptionally low, this feature resulting from the arrangement of underslung rear-axle mounted on full cantilever springs, which has been adopted for this year's models. A considerable up-sweep of the frame has become necessary on this account at the point where it bridges the rear axle. This construction has resulted in bringing the car some 2 in. nearer the ground without restricting the ground clearance in any way. Semi-elliptical springs have been retained for the front axle mounting. Concurrently with the lowering of the rear of the frame, the radiator has been increased in height, and as a result of these two changes, the top of the radiator is now practically level with the line of the body coping, a moderate up-sweep being given to the dash-panel towards its centre. The resulting body lines are very pleasing. The track has been increased from 4 ft. 6 in. to 4 ft. 7 in., giving more width to the seats.

The engine is an overhead valve model of 75 mm. bore by 120 mm. stroke, the Treasury rating thus being 13·9 h.p. The water circulation is by centrifugal pump mounted above the level of the engine bearers and the pump shaft is carried through towards the rear and serves to drive both the dynamos and magneto, the three units being in line on the near side of the engine. Lubrication is by pressure feed to all bearings. A Claudel-Hobson carburettor is mounted at the base of a vertical branch of the induction manifold, which is on the off side of the engine. The exhaust manifold is mounted above, and parallel to, the induction manifold. The appearance of the engine as a whole is particularly neat. A single plate clutch transmits the power to a three-speed gear box, the whole forming one unit in the usual way. The gear ratios are 4·75, 7·92, and 13·9 to 1, the reverse gears being of the same ratio as the first. Internal-expanding brakes operated by the foot pedal are fitted on all four wheels, an additional pair of brakes of the same type being provided on the rear wheels for hand operation.

The only other point calling for special comment is the steering, which is of somewhat unusual construction for a modern car. The steering shaft carries a screw which engages with a bronze nut lined with white metal, the movement of this

nut operating the steering lever by means of a hardened steel trunnion. This form of steering was common in the earlier days of the industry, but was abandoned in favour of the worm and sector by the great majority of manufacturers. The Sunbeam Motor Company claim that when properly carried out, it is possible to adopt unusually large bearing surfaces, the resulting wear being less than with the worm and sector type of steering.

Messrs. Lea and Francis, Limited, of Coventry, have adopted the policy of concentrating on one model only, and since its introduction their 10 h.p. car has met with general approval as an exceptionally sound engineering job. A number of improvements have been embodied in the latest model, which we illustrate in Figs. 56 and 57, on page 614. In conformity with the latest practice for this type of car, the engine is an overhead valve model, having a bore of 63 mm. and a stroke of 100 mm., giving a capacity of 1,247 c.c. and a Treasury rating of 9·8 h.p. The head is detachable, and the valves are operated by tappet rods, the camshaft being housed in the crank-case. The overhead valve mechanism is completely enclosed in an aluminium cover, and as the tappet rods are also enclosed, the appearance of the engine is much neater than that usually obtained with this type of valve operation. The valves are of nickel steel, and the valve guides are removable. The makers adhere to cast iron as the material for the pistons, a practice which is rapidly becoming the exception for small engines. Lubrication is effected by a plunger pump situated in the sump and operated by an eccentric drive on the camshaft. Additional lubrication to the overhead valve rockers is afforded by an oil wick. The dynamo is positively driven and is situated just below the tappet inspection cover on the near side of the engine, the starter being on the same side and housed in an extension of the flywheel casing. A Zenith carburettor is mounted on the off side of the engine, and the exhaust manifold, of the usual ribbed pattern, is on the near side. The B.L.I.C. magneto is driven by spiral gears and is mounted on the front of the engine, its axis being at right angles to the engine line. This arrangement brings the contact breaker into a very accessible position on the off side of the engine. The engine develops 19 h.p. at 2,000 r.p.m., which is quite a good performance.

Unit construction is adopted for the engine and gear-box, an inverted leather-to-metal cone clutch being fitted. The cone is of aluminium alloy. The gear-box is of somewhat unusual construction in that the gear shafts, gears, and striking forks are all mounted on the rear cover of the gear-box. The whole of the gear mechanism can thus be assembled as a complete unit before being inserted in the box. A positive locking device renders it impossible for two gears to be in mesh at the same time. The gears are arranged for four forward speeds, the ratios being 4·7, 7·36, 11·2 and 18·8 to 1. The reverse gear is exceptionally low, being 24·6 to 1. Both the gear wheels and the shafts are manufactured from nickel-chrome steel. The gear-change lever is arranged for right-hand control, the gate and lever being carried by a tubular casting bolted to the gear-box proper.

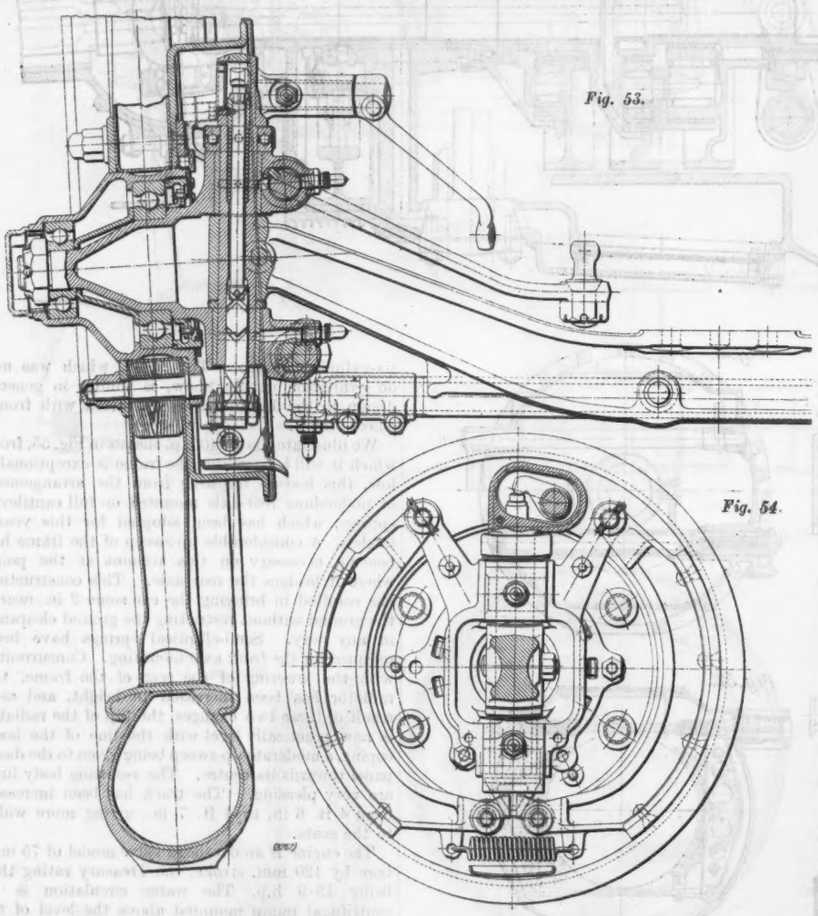


Fig. 53.

Fig. 54.

The rear axle is of especial interest in that it is made up of two aluminium alloy castings, which are bolted together circumferentially at the centre to form the complete casing. The differential is of the spur gear type, and the final transmission is by spiral bevel. The bevel pinion is mounted on two ball races carried by a separate aluminium alloy housing, which is bolted to the main axle assembly after the latter has been assembled. The axle shafts can be removed from the casing without disturbing the assembly. The axle mounting is somewhat unusual, a comparatively short torque arm being provided. This arm is arranged to take up the rear axle torque only, the propeller shaft torque being taken by the springs. The torque arm has a vertical hinge at its rear end, the front end being mounted on a cross frame member introduced for the purpose. A spring-loaded shock absorber is introduced at this point. The propeller shaft is a hollow tube, and is fitted with a flexible disc universal joint at each end. Semi-elliptical springs are fitted on the front axle and quarter-elliptical springs on the rear. As the torque arm pivot is practically opposite the spring anchorage, there will not be much movement of the loose end of the springs on the axle, but any movement which occurs is taken up by the spring brackets on the axle being free to rotate on the axle casing.

The foot brake follows normal practice, there being a brake of the internal expanding type operated by the foot pedal on each wheel. The hand brake is also of the internal expanding type and is in a very unusual position, being mounted as a transmission brake operating on a drum attached to the bevel pinion shaft. It is operated by a cable, and the arrangement of the mechanism at this point hardly impresses us favourably. The pinion shaft bearings have normally a heavy duty to perform, and we do not think that it is advisable to call upon them to take up the additional load which may be imposed when wear takes place in the brake, a side thrust action when the brake is applied being very possible under such circumstances.

The front axle is of the usual I-section and is of nickel steel. The pivot pins work in phosphor-bronze bearings and are supported by a large hardened steel ball, with an adjustable hardened steel cup. The stub axles are of the forked type, and are designed to give a positive castoring action.

In conclusion a correction should be made in connection with our previous article. On page 579 the crank-connecting rod ratio of the Bentley car was given as 295 : 149. It should have been 3·96 : 1.

HYDRAULIC TURBINES AT THE BRITISH EMPIRE EXHIBITION.

In view of the bid now being made by British manufacturers to secure a good share of the considerable amount of business being done in connection with hydraulic plants, this branch of engineering can hardly be said to have been adequately represented at the British Empire Exhibition. The public, who are, of course, naturally attracted by the spectacular orders for large installations recorded from time to time in the press, are, however, rather apt to forget that this form of development is not restricted to large schemes, and that smaller installations are often being made, especially in countries such as this, in which heads and volumes are not large, though supplies are fairly regular or easily regulatable on a moderate scale.

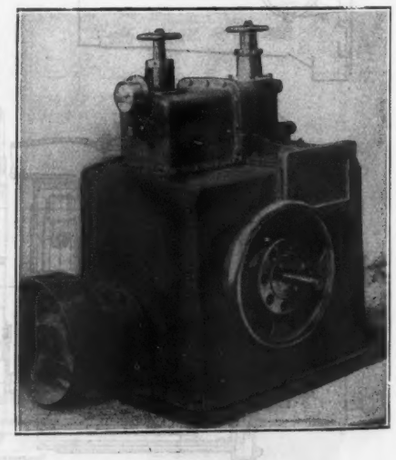


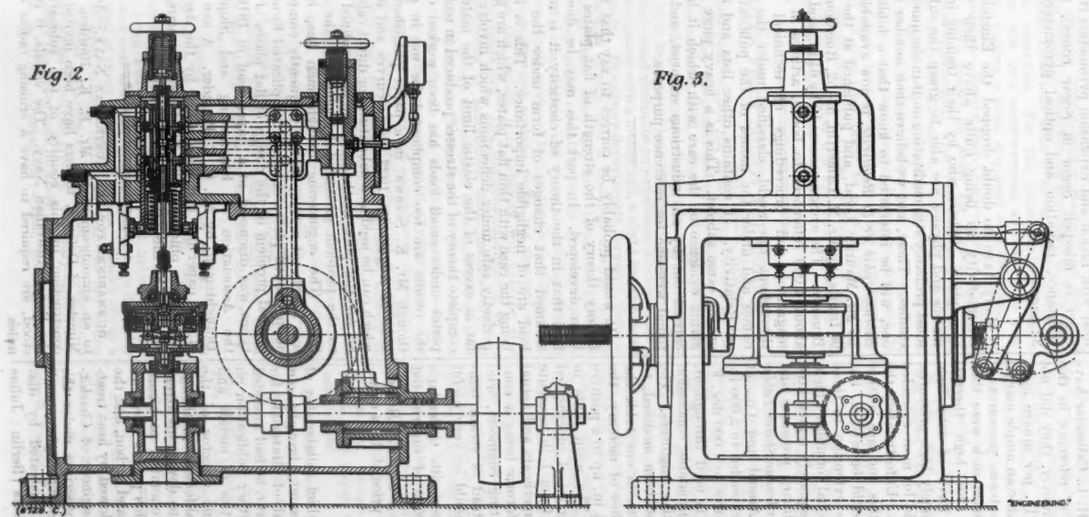
Fig. 1.

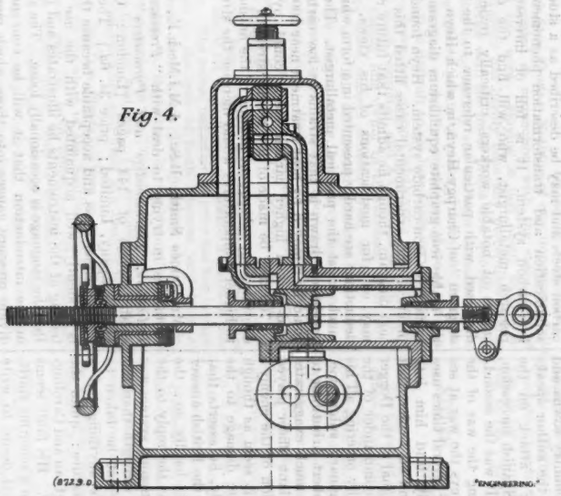
One of the firms making a particular business of the more moderate schemes is Messrs. Joseph J. Armfield and Co., Limited, of Ringwood, Hants. This firm has been connected with the building and installation of hydraulic power plants for over forty years, and have experience with a variety of types of turbines, some of which are shown at their stand in the Palace of Engineering.

The most interesting part of their exhibit is possibly their new oil-pressure turbine governor, which we illustrate in Figs. 1 to 4 on this page and opposite.

HYDRAULIC TURBINES AT THE BRITISH EMPIRE EXHIBITION.

CONSTRUCTED BY MESSRS. JOSEPH J. ARMFIELD AND CO., LIMITED, ENGINEERS, RINGWOOD.





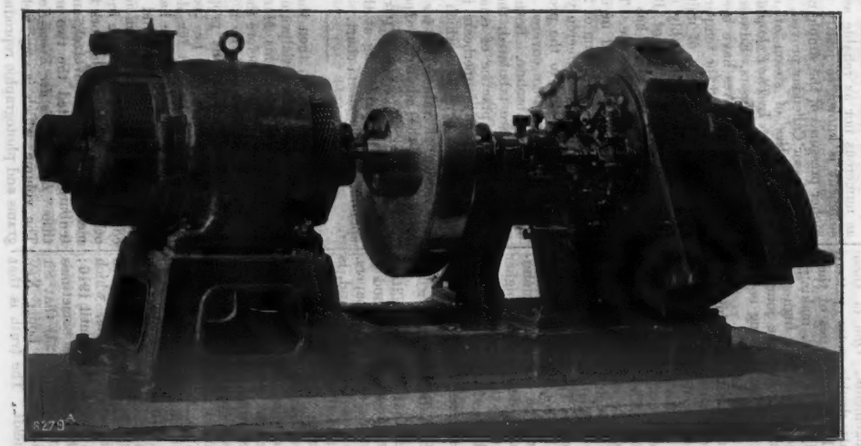
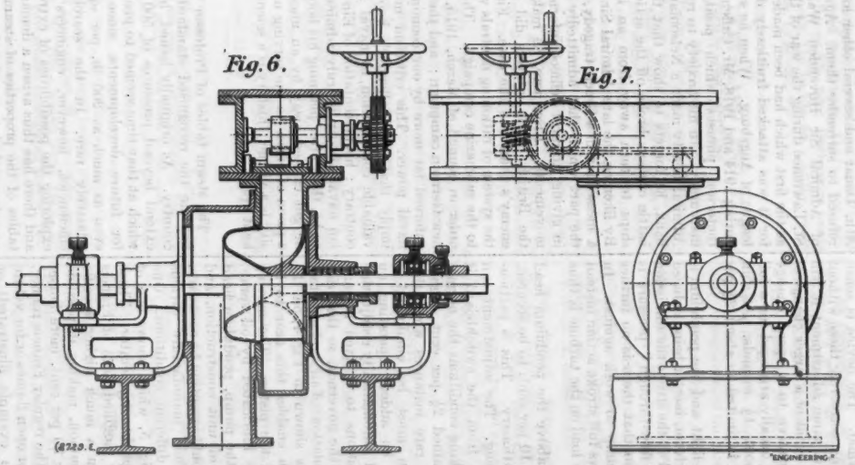


FIG. 5.



This governor is designed on the "flow through" principle, oil being in constant circulation, instead of being maintained under pressure. The governor is belt driven, and on the pulley shaft, inside the casing, is an oil pump of the gear type (see Figs. 2 and 4). A supply of oil is maintained inside the governor box casing, the pump being flooded. The oil is forced up the sloping connection in Fig. 2, to the control valve gear shown on the top of the casing. The governor is driven by worm gearing (see Figs. 2 and 3), and runs at over 1,000 r.p.m. It is mounted in ball bearings and contains spring-controlled pendulum weights, which, on the speed rising, lift, by means of cranks in the revolving head, a small spindle terminating above in a cap. Supported by a ball, on this cap, is a pilot valve, working within the main cylindrical valve above. The pilot valve is raised by the action of the governor, against the pressure exerted by an adjustable spring. The main valve is also provided with a spring underneath. When the turbine is running at normal speed the oil delivered by the pump simply circulates through the valve passages and returns to the reservoir. If the pilot valve is raised, the oil delivered by the pump is passed to the under side of the main valve, raising this, when ports are uncovered and oil passes to the piston controlling the gate gear, and shown in Fig. 4. The pressure rises slightly until the mechanism operates.

The main valve does not work in a fixed bush or liner, but in a movable sleeve. This sleeve is provided with lugs at its lower end, and pins fitted to these work in blocks sliding in oblique guides. The slant of these guides is set to suit the condition of operation. The sleeve is raised and lowered through the action of a rod and rocking lever shown in Fig. 3, coupled to the gate control rod crosshead by short links. When the piston (Fig. 4) is moved under the action of the governor and valve gear, the sleeve is also moved, and this movement re-covers the admission ports and re-opens the flow through passages so that the piston movement is checked. The extent of the piston movement depends upon the slant of the compensating sleeve guides, and the variation of speed from the normal. With a sudden big change of speed

the piston movement is unchecked and continues thus until the speed falls to normal. The device is sensitive to the smallest variations, correcting these without any hunting, while with the same adjustment it will operate at full speed in the event of a larger change of load. The governor is sensitive to a speed change of about ¼ per cent. and is usually arranged for a full range closing time of about 1½ seconds. At full stroke the speed variations is limited to about 2½ per cent.

The pilot valve is very light and the pendulum is given very little work to perform, inertia being reduced to a minimum. At the end of the stroke the admission ports being closed, only "flow-through" pressure is maintained on the piston so that there is no further rise of pressure for the pump to work against. In fact, a fall of pressure follows full stroke action instead of the common rise, and the load on the turbine is thus reduced.

The compression spring above the pendulum head enables a range of speed of 10 per cent. to be secured, either while running or stationary. This is particularly useful for synchronising. The adjustment can be arranged for operation from the switchboard if desired. For ordinary working conditions the normal speed at no-load is maintained 2½ per cent. higher than at full-load. In the rare instances when this permanent speed variation must be eliminated a synchronising device can be added, operating on the compression spring, and automatically readjusting the speed at all gate positions to a fixed normal. There are no dash-pots in the governor, so that risk of irregularity, due to accumulations of air, is eliminated. The hand gear operates, as shown in Fig. 4, on the main piston rod; a clutch enables this gear to be engaged at any position of the piston. The moving parts inside the casing are lubricated by oil spray. The various parts such as the pump, pendulum head and valve mechanism are of unit construction, and can be removed complete should attention be necessary.

Messrs. Joseph J. Armfield manufacture various types of turbines to meet different conditions. One of these is illustrated in Fig. 5, which shows one of their "River" turbines coupled to a generator. These turbines have a mixed flow modified form of Francis runner and the firm claim a much higher specific speed for them than is common, making it possible in some cases to instal over 30 per cent. more horse-power than is possible with the regular Francis runner. The turbines are designed for open flumes or for volute pressure casing (as in the example illustrated) or in a variety of other arrangements. One of these includes the horizontal shaft double rotor pattern with single draught tube. The guide vanes of these turbines are operated by adjustable links, making it possible to take up wear separately. For high-speed installations ball bearings are fitted to the journals, and to take up the thrust. Metallic packing is used for the glands.

Another example of the firm's turbines is illustrated in Figs. 6 and 7. The range of turbines represented by these figures is one of the mixed flow class. It is known by the name of the "British Empire" type. It is usually made of cast iron throughout, the water passages being clean and open. The water is guided to the wheel by a volute pressure casing to which is fitted a regulating gate box, in which the gate valve is operated by rack and pinion worked from the outside by handwheel and worm gear. These turbines are built in either single or double rotor patterns up to 70 in. in diameter. Another type of turbine manufactured by Messrs. Armfield is designed for higher heads than the two foregoing, while the firm also manufacture Pelton wheels, waterwheels of various types, &c.

NOTES ON NEW BOOKS.

Modern scholarship demands that civil and military history shall be based on a micro-analytic method of research into original documents and state papers. The intelligent reading public, on the other hand, is quite prepared to study historical works which, like Mr. Geoffrey Callender's book on "*The Naval Side of British History*" (Christophers, London. Price 4s. 6d. net), are based only on wide reading. The author has adapted the scope and arrangement of his work to their taste and has written it in a readable style. More than this, he is one of the first naval historians whose review of British marine history is more than a mere record of campaigns and battles. This, in itself, is a great achievement. The book must, however, be read with a certain amount of caution. In the first place Mr. Callender's review of British naval strategy is misleading; he gives no inkling of the controversy between the continental and amphibious strategists, which opened in 1689, and went on, unbrokenly, until 1916; and in the second place the author is sometimes weak as to facts. He states (page 123) that Sir William Temple's triple alliance made Louis XIV evacuate the delta of the Scheldt. The truth is that Louis had not occupied it; but had seized Lille, Condé, Ath, Douai and several other low country towns and refused to surrender them. Again the author speaks of Admiral Sir Hovenden Walker's attack on the St. Lawrence during the war of the Spanish succession, as the first which had been made. It was the second: for it was attacked fruitlessly during the war of the league of Augsburg. When he surveys the war at sea during 1914 and 1918, Mr. Callender several times uses rhetorical phrases which positively lead him into inaccuracy. In his anxiety to remind his readers that Admiral Beatty made a Nelsonian signal at the Dogger bank, he forgets to show that the commander of the battle cruisers broke off the action by ordering all his ships to turn away from an imaginary submarine. By likening the late Admiral Sir Robert Arbuthnot to a messenger in a Greek tragedy, he much exaggerates the part which that admittedly gallant officer played in giving Admiral Jellicoe information of the enemy's movements. Elsewhere, he makes it seem as though the British battle cruisers did more damage to the enemy's than was the case. Finally, he asserts that the system of rationing neutrals was the British answer to the submarine campaign. This is hardly so: the order in council of March, 1915, was the reply to the new German campaign; and the rationing system was enforced far more by our economic strength than our naval power. This criticism must not be taken to imply that Mr. Callender's book is anything but a valuable contribution to naval literature: quite the contrary; his presentation of Elizabethan and Carolingian naval history is truly admirable. His fault seems to be, that, after planning his book in a scientific spirit, he got carried away by an uncritical desire to write a pæon of praise to the serving naval officer. Generosity is a virtue: history is a science; and they must be kept apart.

The steam tables of Professor H. L. Callendar have become the recognised standard of reference in this country. As originally issued, however, they did not extend beyond pressures of 500 lb. per square inch, which at that time seemed to provide an ample margin for future developments, since steam pressures of even as much as 200 lb. per square inch were then relatively rare. In the search for high thermal efficiencies, however, engineers have of late been exploring the possibilities of extremely high pressures, and there has thus arisen a demand for more extended tables of the properties of steam. Unfortunately the experimental data available to this end are neither as numerous nor as reliable as could be wished, but sufficient is known to justify the extension to these higher pressures of the simple rational formulas which, as Professor Callendar proved, adequately represented the properties of steam at ordinary pressures and temperatures. In *The Enlarged Callendar Steam Tables* just issued by Messrs. Edward Arnold and Co., at 7s. 6d., the pressures have been extended to 2,000 lb. per square inch, and the temperatures to 1,000 deg. F. The Fahrenheit system of units is used throughout, an unfortunate but probably unavoidable concession to the ingrained habits of British engineers. The arrangement of the tables has also been modified, to facilitate drawing office use. Thus, in one table the "argument" is expressed in inches of mercury, the range being from a vacuum of 29½ in. up to a positive pressure of 30 in. of mercury. The main table in the book is devoted to the properties of superheated steam, and the range covered is from 1 lb. absolute up to 2,000 lb. absolute. Both superheats and actual temperatures are tabulated, the former being a concession to the practice of consulting engineers, who commonly specify superheats instead of steam temperatures. A new table which should be very useful is a series of values $P^{\frac{1}{n}}$ for use with Callendar's formula for the adiabatic expansion of superheated steam according to which $T/P^{\frac{1}{n}}$ = constant. Messrs. Arnold are also publishing at the price of 1s. a corresponding Mollier steam chart.

When Dr. E. Heyn, then the chief collaborator of Martens in the Materialprüfungsamt, brought out the second volume of his Manual of Materials for Machine Construction, before the war, he had intended to supplement this work by a further publication on the technically important properties of metals and alloys. After the war he became director of the Kaiser Wilhelm Institut für Metallforschung, though in indifferent health, and he had to devote his attention largely to industrial and economical problems. He died in March, 1922. Among his papers were two complete manuscripts, one on iron and carbon, and the other on the effect of cold work followed by heat treatment. Professor E. Wetzel, an engineer of Charlottenburg, has edited the two manuscripts under the title "*Die Theorie der Eisen-Kohlenstoff-Legierungen.*" The volume, which is very well illustrated by diagrams and photographic reproductions [Berlin: Julius Springer; price 2·90 dols.], deals chiefly with low-carbon steels and may be described as a study of the solidification and transformation phenomena in the iron-carbon system. It is full of interest to the research metallurgist, who will find the data and curves of notable workers critically reviewed and discussed with particular reference to the "double-diagram" of Charpgy-Heyn, in which Heyn combines the stable iron-graphite equilibrium diagram and the metastable iron-carbide system. Heyn found that all practical and experimental cases fitted this combination diagram, though he admits that future researches may call for modifications of his views. But the deductions are hardly presented in a form which would much assist the practical metallurgist. The general conclusion drawn is that strains in low carbon steels could be removed by heat treatment near 500 deg. C.; cold-worked higher carbon steels could by heating to 700 deg. be made of low tensile strength and high ductility, but subsequent heating of the finished article to higher temperatures would increase the strength.

Mr. James Smith, B.Sc., A.M.I.Mech.E., is rather ambitious in trying to deal with "*Pressure Gauges, Indicators, Thermometers and Pyrometers*" in one small volume of 144 pages [London: Constable and Company, Limited; price 3s. 6d.] The book is of the primer class and acceptable because the author is evidently well acquainted with the use and the testing of the instruments he illustrates and describes. But the language is occasionally loose. The statement in the introduction that it will be convenient "to divide pressure gauges into those which measure the pressure of gases, such as air, steam, ammonia, and those which measure the pressure of liquids, such as water, oil, &c.," does not prejudice the reader in favour of the volume. The last four chapters on pyrometers deal with fusion and expansion pyrometers (the name Seger is misspelt Segor in Segar cones), platinum resistance, radiation and optical pyrometers, all in 32 pages.

Many have no doubt dropped the Einstein theory of relativity as being quite above their range of conception. Others who by their training in mathematics and physics are able to grasp the subject are most probably still meditating on it in the quiet of their studies. These, and we believe their number is a large one, will be interested to know that a bibliography, *Bibliographie de la Relativité*, is now available, edited by Mr. Maurice Lecat, and published at the price of 90 francs, by Mr. M. Lamertin, 58–62, Rue Coudenberg, Brussels. The work measures 10 by 6½ in., and contains about 4,000 references to books, articles in journals, magazines and proceedings of technical societies throughout the world, classified under the authors' names and under the names of the publications, all on Relativity. It contains other lists and statistics on the same subject. This is a heavy piece of work, giving evidence of the care with which it has been carried out by an industrious scientist, and will be found welcome for reference purposes.

It would probably be correct to say that no satisfactory theory of the strength of flat plates has yet been developed. In part this may be due to the fact that in the theory of elasticity it is implicitly assumed that changes of form under the imposed load are of negligible importance. This is far from being the case with thin flat plates, which are generally perfectly safe under deflections which involve stresses far in excess of the elastic limit of the material. A complete theory of the stresses produced in rectangular plates under small loads has been worked out, but the results are too complicated for use in practice, though Mr. K. Sezawa, in a paper published in our issue of August 10, 1923, gives curves and diagrams which can be used as a substitute for direct calculation. So far the pure mathematician has confined himself to the problem presented by plates of the simplest form. The engineering draughtsman has, however, less liberty of action, and is frequently compelled to adopt ribbed plates or other complicated forms. The general problem of the design of flat plates of various types was discussed in a paper read in 1919 before the Association of Engineering and Shipbuilding Draughtsmen, by Mr. C. C. Pounder. A new reprint of this paper has just been issued by the Association from their offices at 96, St. George's-square, Westminster, at the price of 2s. per copy.

Submarines for the Australian Navy.—According to an announcement by Mr. E. K. Bowden, Federal Minister of Defence, tenders have been invited for the construction in this country of two submarines for the Royal Australian Navy. The vessels, it is understood, are required to have a cruising radius of 3,000 miles.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—Nothing of any importance falls to be recorded in connection with the steel trade of Scotland this week. Buying is just about as slow as ever, and there has hardly been any perceptible change for the better with the lower prices now quoted. These have failed to cause any stir amongst consumers, who are being offered plenty of material from the Continent and the South at even lower prices than those of the local makers. It is difficult to see how these very low quotations can leave any margin whatever. The output all round is much restricted, and a considerable amount of plant is totally idle owing to the absence of demand. The black sheet makers continue busy on light sheets, but there is a lull in forward placings. Galvanised qualities are moving freely, but heavy gauge sheets are still very slow of sale. Prices for home requirements are as quoted last week: Boiler plates, 13*l.* per ton; ship plates, 9*l.* 15*s.* per ton; and sections, 9*l.* 10*s.* per ton; and sheets, $\frac{1}{16}$ in. to $\frac{1}{4}$ in., 12*l.* per ton, all delivered Glasgow stations.

Malleable Iron Trade.—No improvement has taken place in the West of Scotland malleable iron trade over the week. The recent reduction in price has not brought out much in the way of fresh business, and from all appearances there seems little prospect of any decided improvement in the trade in the immediate future. The current quotation for "crown" bars is 12*l.* per ton, delivered Glasgow stations. The re-rolled steel branches are exceedingly quiet and little new dealing is recorded.

Scottish Pig-Iron Trade.—There is still little change to report in the state of the Scottish pig-iron trade as buyers are still far from numerous. The home consumption is very poor, both of hematite and foundry grades, while export sales are just about as low as they have been for many a long day. Prices are nominally unchanged, but are inclined to sag. The following are the current quotations: Hematite, 4*l.* 15*s.* per ton delivered at the steelworks; foundry iron, No. 1, 4*l.* 15*s.* per ton, and No. 3, 4*l.* 10*s.* per ton, both on trucks at makers' yards.

Scottish Pig-Iron Shipments.—The shipments of Scottish pig-iron from Glasgow Harbour for the week ended last Saturday, October 25, amounted to 1,243 tons. Of the total, 1,096 tons went to foreign destinations and 147 tons coastwise. For the corresponding week of last year, 958 tons went overseas and 379 tons went coastwise, making a total shipment of 1,337 tons.

Shipbuilding.—Messrs. Barr, Crombie and Co. (Limited), Glasgow, have placed an order for a cargo vessel of 8,200 tons deadweight, with the Greenock Dockyard Company (Limited), Greenock. Triple-expansion reciprocating engines will be supplied by Messrs. John G. Kincaid and Co., Limited, Greenock. It is exceedingly interesting to note that Messrs. Barr, Crombie and Co. received a more favourable offer from the Continent, but preferred to give their order to a local firm so as to provide employment for Clyde workers. It is to be hoped that the workmen will appreciate this patriotic spirit and act accordingly.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—Until the disturbance caused by the General Election has passed and more normal conditions have been restored, local industry will have great difficulty in making any appreciable headway in order to recover from the present long-standing depression. The heavy steel trade continues to experience anxious times, but, as compared with a month ago, a slight improvement is noticeable. In railway departments, however, there is still a lack of orders, and if bookings are not quickly forthcoming many firms may find themselves hard put to it to keep plant operating at its present capacity. Makers of axles, wheels, and tyres are mainly confined to colliery repair work. The call for shipbuilding steel, marine castings, and turbine parts has slumped somewhat, but the decline, it is believed, will only be of a temporary character. The Midlands continue to be the chief consumers of automobile steel manufactured in this district, though the demand in comparison to that before the McKenna Duties were abolished shows a distinct falling off. In the implement and machinery sections, the position remains practically the same. The Colonies are big buyers of agricultural implements; contemplated schemes of irrigation, road construction, and engineering developments are expected shortly to call for large supplies of local products. Colliery development in South Yorkshire continues apace, involving an increased demand for mining implements, pit-head and winding gear. The lighter trades are making steady progress. Output in some cases exceeds that of pre-war periods. Australia and New Zealand are taking increased supplies of garden tools, hammers, pincers, files, picks, shovels, spades, forks, and general engineers' tools. Russia is also doing business in saws on a strictly cash-with-order basis.

South Yorkshire Coal Trade.—The output at pits continues to be in excess of the demand, and at some collieries short-time working is probable. Best steams are active for home consumption, while in contrast the amount going away for export is still below normal. Cobbles and nuts are weak, and merchants have difficulty in disposing of them at reduced prices. Slacks are in a similar position, though the better qualities are selling better. Recent advances in house coal are maintained despite weakness in inferior grades. Foundry and furnace coke are only moderate both on home and export account. Gas-coke is firm. Quotations:—Best branch, handpicked, 32*s.* to 35*s.*; Barnsley best Silkstone, 26*s.* to 28*s.*; Derbyshire best brights, 27*s.* to 32*s.*; Derbyshire best house, 24*s.* to 26*s.*; Derbyshire best large nuts, 22*s.* 6*d.* to 25*s.*; Derbyshire best small nuts, 14*s.* to 16*s.* 6*d.*; Yorkshire hards, 21*s.* 6*d.* to 23*s.* 6*d.*; Derbyshire hards, 21*s.* to 23*s.*; rough slacks, 11*s.* to 13*s.* 6*d.*; nutty slacks, 10*s.* to 12*s.*; smalls, 6*s.* to 8*s.* 6*d.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—The volume of trade passing shows some little expansion, and the supply of Cleveland pig iron is no more than sufficient for current needs. Stocks are small and are stated to be oversold. Makers are thus in quite a strong position, and could not deal with any material increase in demand except by re-kindling idle plant, a step they cannot be expected to take with prices on their present unremunerative level. Producers are using a large proportion of the output at their own consuming works. No. 1 quality continues scarce, and is selling at 85*s.* The f.o.b. quotation for No. 3 g.m.b. is 80*s.*, but the ruling quality is obtainable f.o.t. makers works at 79*s.* 6*d.* No. 4 foundry is 79*s.* and No. 4 forge 78*s.*

Hematite.—What little change is noticeable in the East Coast hematite branch is for the better. Though recent curtailment of output has been insufficient to bring make below needs, and producers are still burdened with heavy unsold stocks, iron is less persistently pressed on the market. Make is now little in excess of requirements, and manufacturers are taking a rather firmer stand. Nos. 1, 2 and 3 are 87*s.* 6*d.*, and No. 4 is 88*s.*

Foreign Ore.—Business in foreign ore is difficult to arrange, and prices are weak. Whilst sellers still base market rates on best rubio at 21*s.* 3*d.* c.i.f. Tees, it is understood that orders can be placed on lower terms.

Blastfurnace Coke.—Durham blastfurnace coke is in only moderate request, but good average qualities keep quietly steady at round about 25*s.* delivered to users in this district.

Manufactured Iron and Steel.—Conditions in manufactured iron and steel are little changed. A little more inquiry is circulating in one or two branches, but Continental competition is still keen in both home and foreign markets, and contracts are difficult to secure. Home quotations stand: common iron bars, 12*l.*; iron rivets, 14*l.* 5*s.*; packing (parallel), 9*l.*; packing (tapered), 12*l.*; steel billets (soft), 8*l.* 10*s.*; steel billets (medium), 9*l.*; steel billets (hard), 9*l.* 10*s.*; steel boiler plates, 13*l.*; steel ship, bridge and tank plates, 9*l.* 15*s.*; steel angles 9*l.* 10*s.*; steel joists, 9*l.* 10*s.*; heavy steel rails, 9*l.*; fish plates, 13*l.*; and galvanised corrugated sheets, 18*l.*

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—New business has been rather more active on the coal market during the past week and the outlook is more satisfactory than has been the case for some weeks past. A considerable volume is still required to keep the collieries working regularly and to bring into operation the many pits that have been closed down. The outlook, however, is considered brighter, and business is being transacted for delivery over next year on an increasing scale. In addition to the 250,000-ton order placed by the French Midi Railway and the 400,000-ton contract placed by the Central Argentine Railway, the Entre Rios Railway has also ordered 50,000 tons. The Egyptian State Railways are inviting offers for 200,000 tons of large over the first five months of next year, while the San Paulo Railway of Brazil also want tenders for 85,000 tons of large over the last nine months of 1925. The British Admiralty are also inviting offers for supplies over next year. No definite quantities are stated, but it is the practice of the collieries to quote for definite quantities. In pre-War days the Admiralty took about 1,500,000 tons per annum, but the increasing use of oil fuel has reduced their requirements to about 400,000 tons. Foreign depot proprietors are also "sounding" colliery proprietors, but so far there is a difference of about 2*s.* per ton in the idea of prices. In the meantime chartering operations have been much more active of late, and as shipping has arrived more freely colliery positions generally have been rendered more comfortable, though free supplies of large are still excessive. Best small coals are decidedly firmer, and business has been done at 16*s.* 6*d.*, though the general value is from 15*s.* 6*d.* to 16*s.*, but buyers able to take large as well can secure concessions.

Iron and Steel.—Exports of iron and steel goods in the past week from South Wales amounted to only 11,802 tons, or 8,000 tons less than in the previous week. Shipments of tinplates and terneplates amounted to 8,065 tons, compared with 8,800 tons; blackplates and sheets to 1,139 tons, against 4,629 tons; galvanised sheets to 1,664 tons, against 4,420 tons; and other iron and steel goods to 934 tons, against 1,966 tons. Tinplates are a steady market on the basis of 23*s.* 6*d.* to 23*s.* 7½*d.*, though the actual business passing is only moderate.

PERSONAL.—Messrs. Electromotors, Limited, of Openshaw, Manchester, announce that on and after November 11 their London address will be Australia House, Room 420, Strand, W.C.2.—Mr. J. C. Elvy, consulting engineer, has removed to 3-7, Southampton-street, Strand, London, W.C.2.

NOTICES OF MEETINGS.

THE INSTITUTION OF MECHANICAL ENGINEERS.—To-night, at 7 p.m., at Storey's Gate, S.W.1. Informal meeting. Discussion on "Engineering Novelties at the British Empire Exhibition."

THE JUNIOR INSTITUTION OF ENGINEERS.—To-night at 7.30 p.m., at 39, Victoria-street, S.W.1. Lecturette: "Audio-frequency Transformers," by Mr. H. J. N. Riddle. Friday, November 7, at 7.30 p.m. Lecturette: "History and Construction of the Fire Engine," by Mr. H. C. Jones.

THE INSTITUTE OF BRITISH FOUNDRYMEN: BIRMINGHAM BRANCH.—Saturday, November 1, at 4 p.m., at the Chamber of Commerce, New-street, Birmingham. Lecture on "The Iron Age," by Mr. Thos. Vickers.

THE INSTITUTE OF BRITISH FOUNDRYMEN: LANCASHIRE BRANCH.—Saturday, November 1, at 4 p.m., at the College of Technology, Sackville-street, Manchester. Lecture on "Modern Pattern-making Experience," by Mr. J. A. Stephenson.

THE ROYAL INSTITUTION OF GREAT BRITAIN.—Monday, November 3, at 5 p.m., at Albemarle-street, Piccadilly, W.1. General Meeting.

THE INSTITUTE OF TRANSPORT.—Monday, November 3, at 5.30 p.m., at the Institution of Electrical Engineers, Victoria Embankment, W.C.2. Annual General Meeting, followed by paper, "Transport on the Highway," by Mr. A. E. Bassom.

THE SOCIETY OF ENGINEERS (INCORPORATED).—Monday, November 3, at 5.30 p.m., at the Geological Society, Burlington House, W.1. "Underground London," by Capt. W. J. Liberty.

THE NORTHAMPTON ENGINEERING COLLEGE ENGINEERING SOCIETY.—Monday, November 3, at 5.30 p.m., at John-street, E.C.1, "Ideal Plant for a Transformer Test Room," by Mr. W. Tyson.

THE BRADFORD ENGINEERING SOCIETY.—Monday, November 3, at 7.30 p.m., at the Bradford Technical College. Lecture, "The Gas Turbine," by Mr. Hugh Campbell, M.I.Mech.E.

THE JUNIOR INSTITUTION OF ENGINEERS: NORTH WESTERN SECTION.—Monday, November 3, at 7.30 p.m., at the Manchester Geographical Society, 16, St. Mary's Parsonage, Manchester. Lecture: "Arc Welding," by Mr. R. Woodthorpe Strawson.

THE INSTITUTION OF RUBBER INDUSTRY.—Monday, November 3, at 8 p.m., at the Engineers' Club, Coventry-street, W.1. "Gutta Percha: Preparation and General Properties," by Mr. C. W. H. Howson, B.Sc.

THE INSTITUTION OF PETROLEUM TECHNOLOGISTS.—Tuesday, November 4, at 5.30 p.m., at the Royal Society of Arts, John-street, Adelphi, W.C.2. "The Oilfields of Argentina," by Mr. Campbell M. Hunter, M.A., F.G.S.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, November 4, at 6 p.m., at Great George-street, S.W.1, Opening Meeting: Address by Mr. Basil Mott.

THE MANCHESTER METALLURGICAL SOCIETY.—Tuesday, November 4, at 7 p.m., at the College of Technology, "Properties of Metals at High Working Temperatures," by Prof. F. C. Thompson, D.Met., B.Sc.

THE INSTITUTE OF METALS: BIRMINGHAM LOCAL SECTION.—Tuesday, November 4, at 7 p.m., at the Chamber of Commerce, New-street, Birmingham. "Brazing," by Mr. A. R. Page.

THE INSTITUTE OF METALS: NORTH EAST COAST LOCAL SECTION.—Tuesday, November 4, at 7.30 p.m., in the Electrical Engineering Lecture Theatre, Armstrong College, Newcastle-on-Tyne. "The Structure of Metals in its Relation to Elastic Failure—Part II," by Mr. W. E. W. Millington, M.Inst.C.E.

THE WEST YORKSHIRE METALLURGICAL SOCIETY.—Tuesday, November 4, at 7.30 p.m., at the George Hotel, Huddersfield. Presidential Address. Afterwards discussion on "The Influence of Casting Temperature on the Physical Properties of Non-Ferrous Alloys."

THE INSTITUTION OF ELECTRICAL ENGINEERS: WIRELESS SECTION.—Wednesday, November 5, at 6 p.m., at Victoria Embankment, W.C.2. Address by Mr. E. H. Shaughnessy.

THE INSTITUTION OF CHEMICAL ENGINEERS.—Wednesday, November 5, at 8 p.m., in University College, Gower-street, W.C.1. "The Water Gas Process," by Dr. M. W. Travers, F.R.S.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.—Thursday, November 6, at 2.30 p.m. in the Lecture Theatre of the Institute, Newcastle-on-Tyne: "Standardisation of Colliery Requisites," by Mr. C. LeMaistre.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Thursday, November 6, at 6 p.m., in the Lecture Theatre of the Institution, Savoy Place, Victoria Embankment, W.C.2. "An Electric Harmonic Analyser," by Messrs. J. D. Cockcroft, R. T. Coe, J. A. Tyacke and Prof. Miles Walker, D.Sc.

POWDERED FUEL.—In the paper on "Powdered Fuel" which Mr. F. F. Evans delivered to the Junior Institution of Engineers on October 24, he dealt mainly with the practical design and construction of the equipment. A very good discussion followed which showed marked differences of opinion on the reliability of the pulverisers and on the advantages and disadvantages of the unit system as compared with the central pulverising system.

THE MOTOR EXHIBITION AT OLYMPIA.

(*For Description, see Pages* 609 *and* 610.)

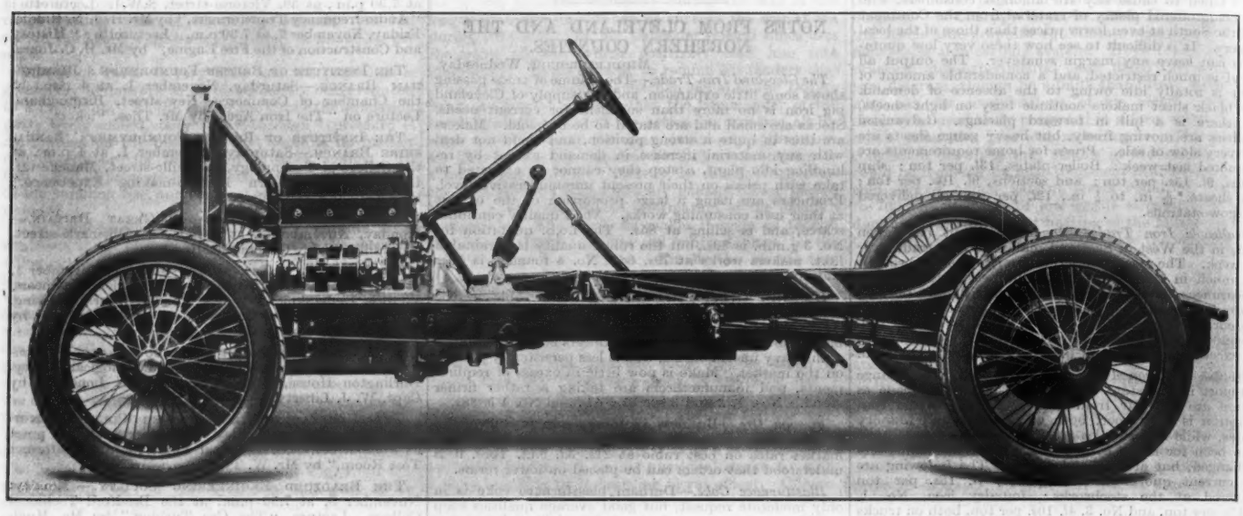


Fig. 55. Chassis of 14/40-H.P. Sunbeam Car.

Fig. 56.

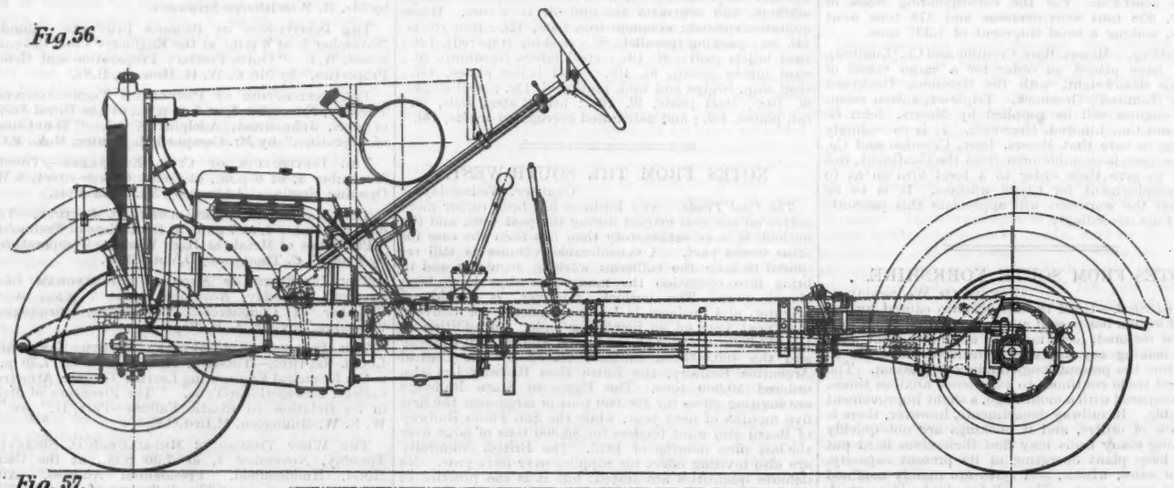
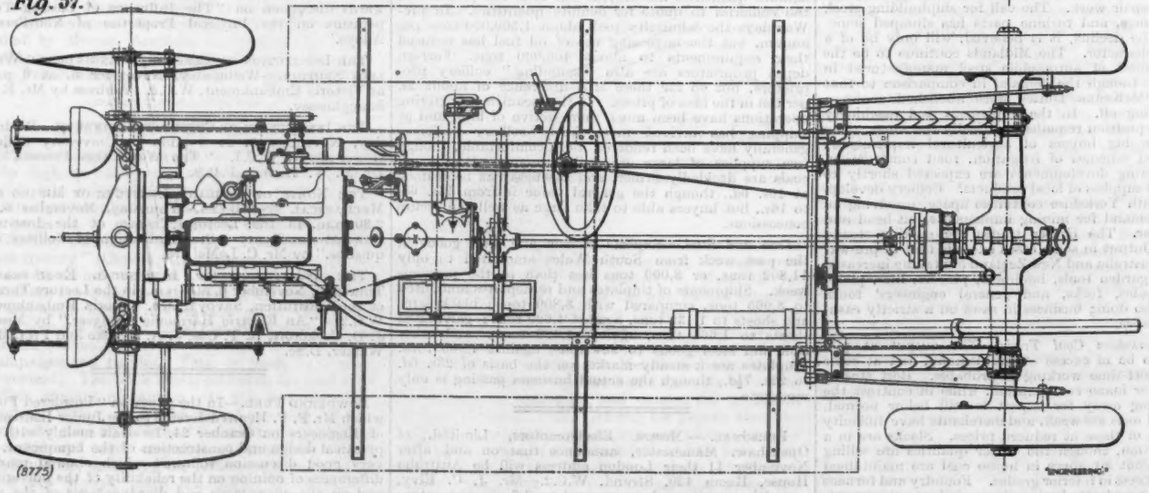


Fig. 57.



Figs. 56 and 57. Chassis of 10-H.P. Lea-Francis Car.

MACHINERY OF THE TWIN-SCREW ORIENT LINER "ORAMA."

CONSTRUCTED BY MESSRS. VICKERS LIMITED, ENGINEERS AND SHIPBUILDERS, BARROW-IN-FURNESS.

(*For Description, see Page* 601.)

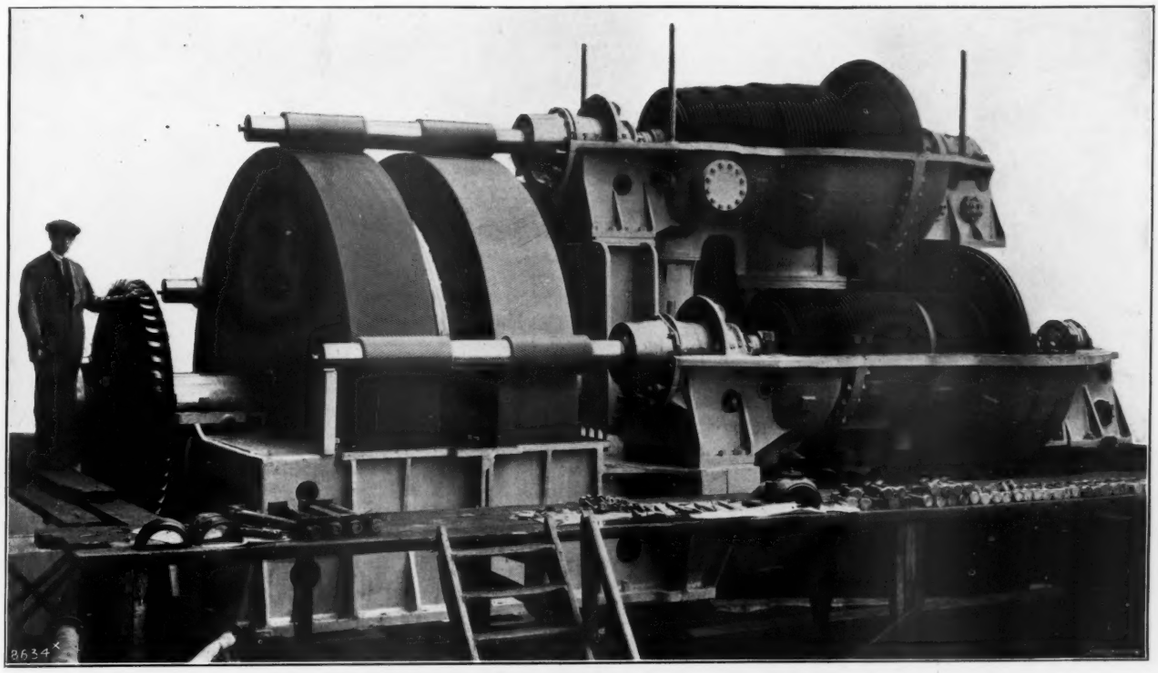


FIG. 13. VIEW OF GEARING AND TURBINES, WITH COVERS REMOVED.

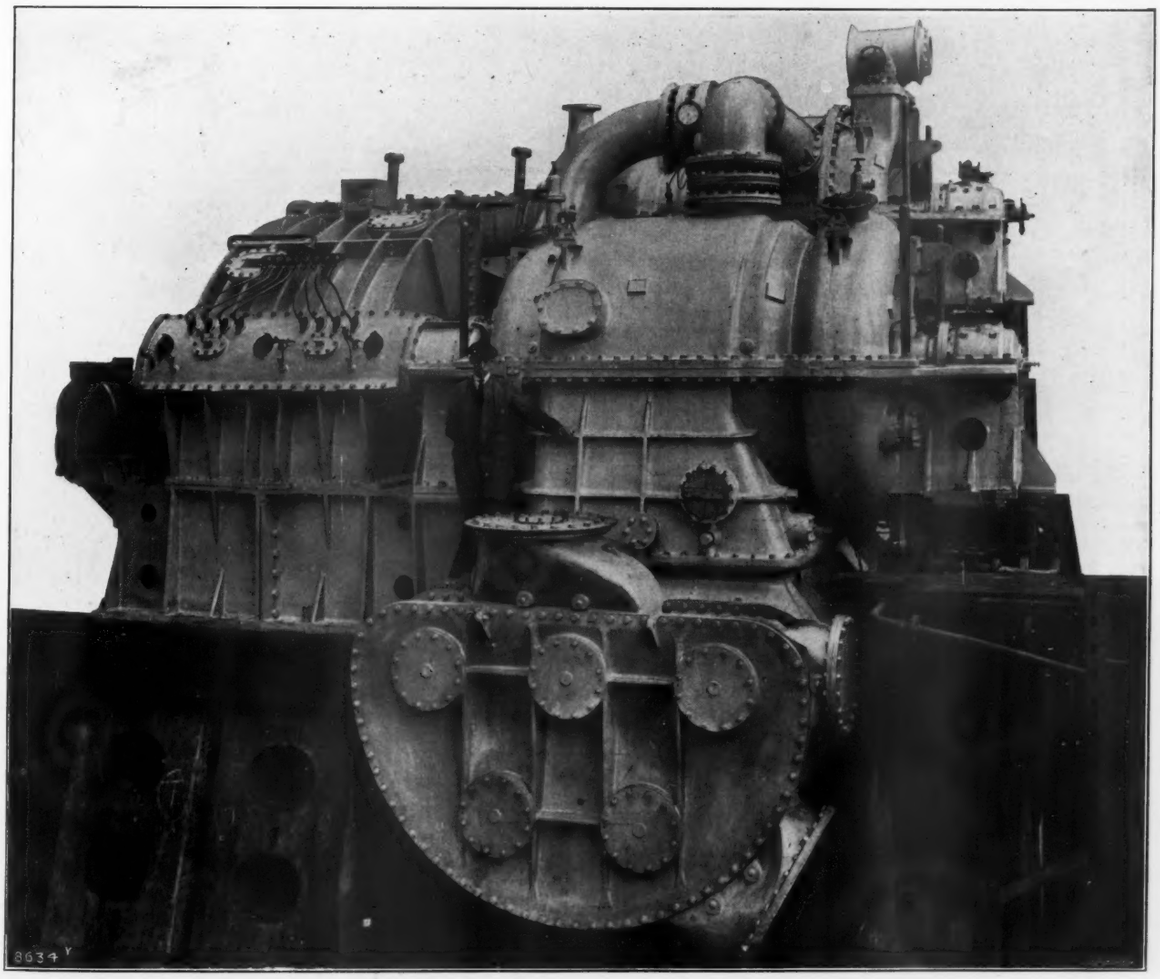


FIG. 14. SIDE VIEW OF TURBINE SET, SHOWING CONDENSER IN POSITION.

(*To face page* 600.)

MACHINERY OF THE TWIN-SCREW ORIENT LINER "ORAMA."

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(*For Description, see Page* 601.)

Fig. 15. ELEVATION AT C.L. OF SHIP (LOOKING TO PORT).

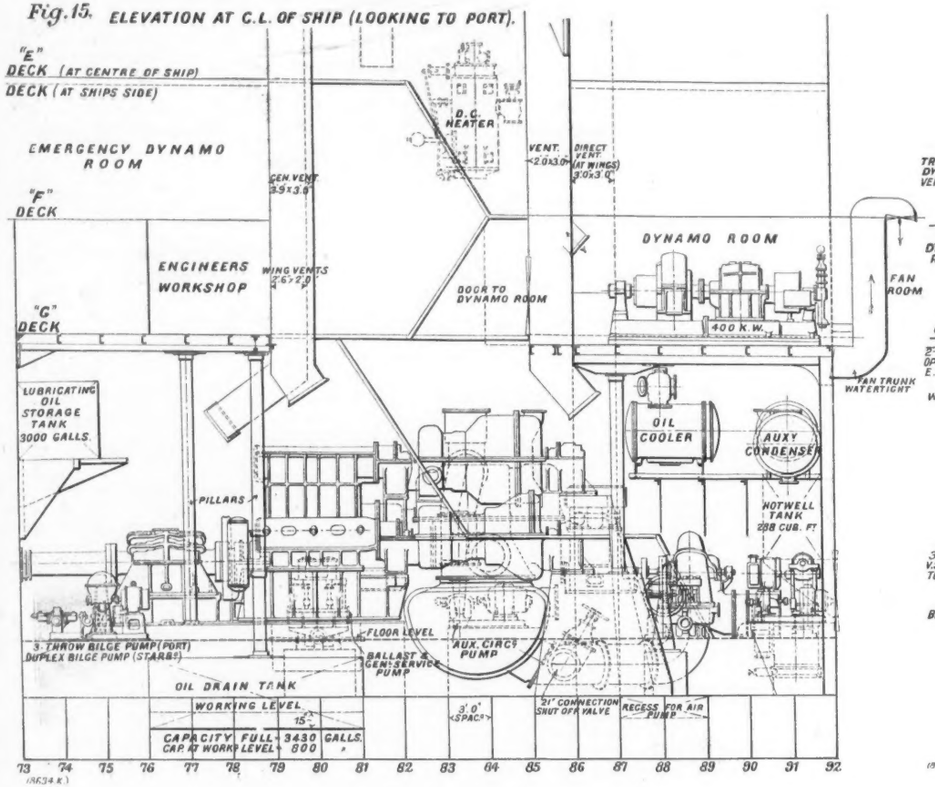

"E" DECK (AT CENTRE OF SHIP)
DECK (AT SHIPS SIDE)
EMERGENCY DYNAMO ROOM
"F" DECK
ENGINEERS WORKSHOP
"G" DECK
D.C. HEATER
VENT. 2.0x3.0
DIRECT VENT (AT WINGS) 3.0x3.0
GEN. VENT 3.9x3.6
WING VENTS 2.6x2.6
DYNAMO ROOM
DOOR TO DYNAMO ROOM
400 K.W.
FAN ROOM
FAN TRUNK WATERTIGHT
LUBRICATING OIL STORAGE TANK 3000 GALLS.
OIL COOLER
AUXY CONDENSER
PILLARS
HOTWELL TANK 288 CUB. FT
FLOOR LEVEL
3 THROW BILGE PUMP (PORT) DUPLEX BILGE PUMP (STARB'D)
BALLAST & GEN. SERVICE PUMP
AUX. CIRC. PUMP
OIL DRAIN TANK
WORKING LEVEL
3'0" SPACE
21" CONNECTION SHUT OFF VALVE
RECESS FOR AIR PUMP
CAPACITY FULL 3430 GALLS. CAP. AT WORK LEVEL 600
73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92

Fig. 19.

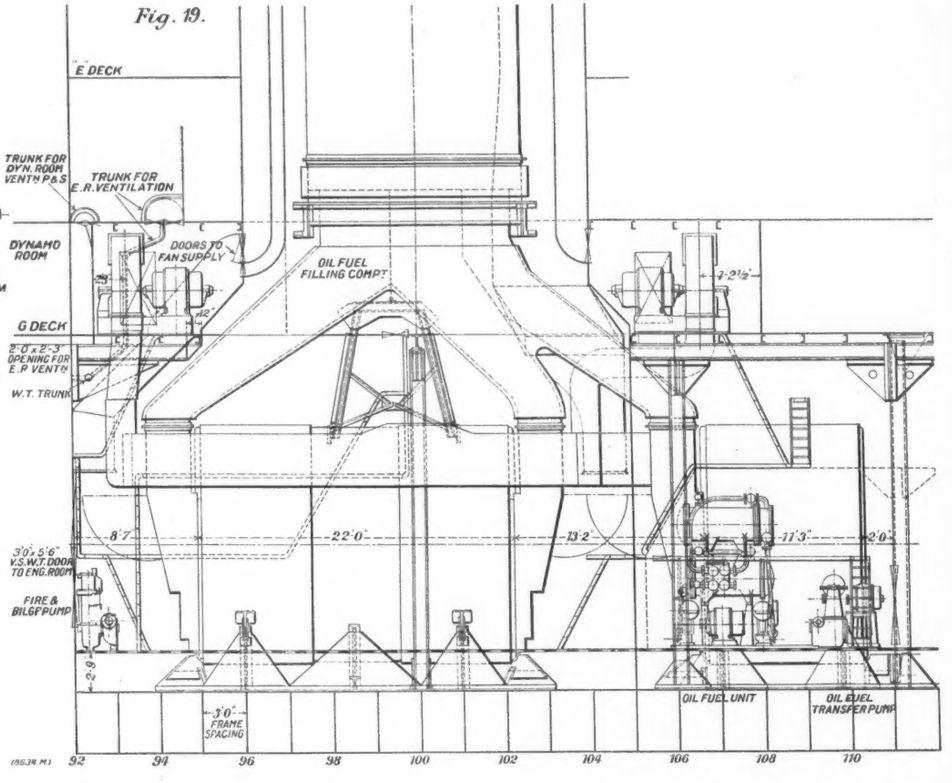

E DECK
TRUNK FOR DYN. ROOM VENTN P.&S.
TRUNK FOR E.R. VENTILATION
DYNAMO ROOM
DOORS TO FAN SUPPLY
OIL FUEL FILLING COMPT
G DECK
2'-0"x2'-3" OPENING FOR E.R. VENTN
W.T. TRUNK
3'0"x5'6" W.S.W.T. DOOR TO ENG. ROOM
FIRE & BILGE PUMP
8'7 22'0 13'2 11'3 2'0
3'0" FRAME SPACING
OIL FUEL UNIT
OIL FUEL TRANSFER PUMP
92 94 96 98 100 102 104 106 108 110

Fig. 16.

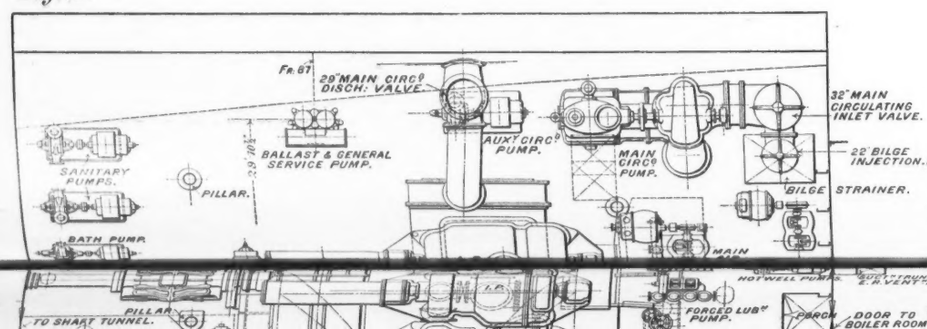
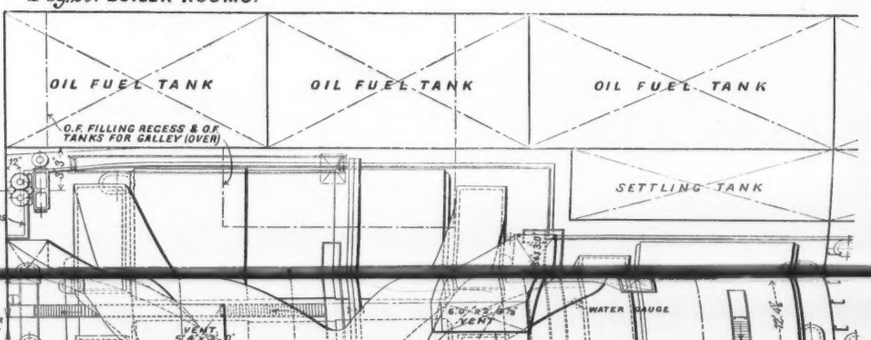
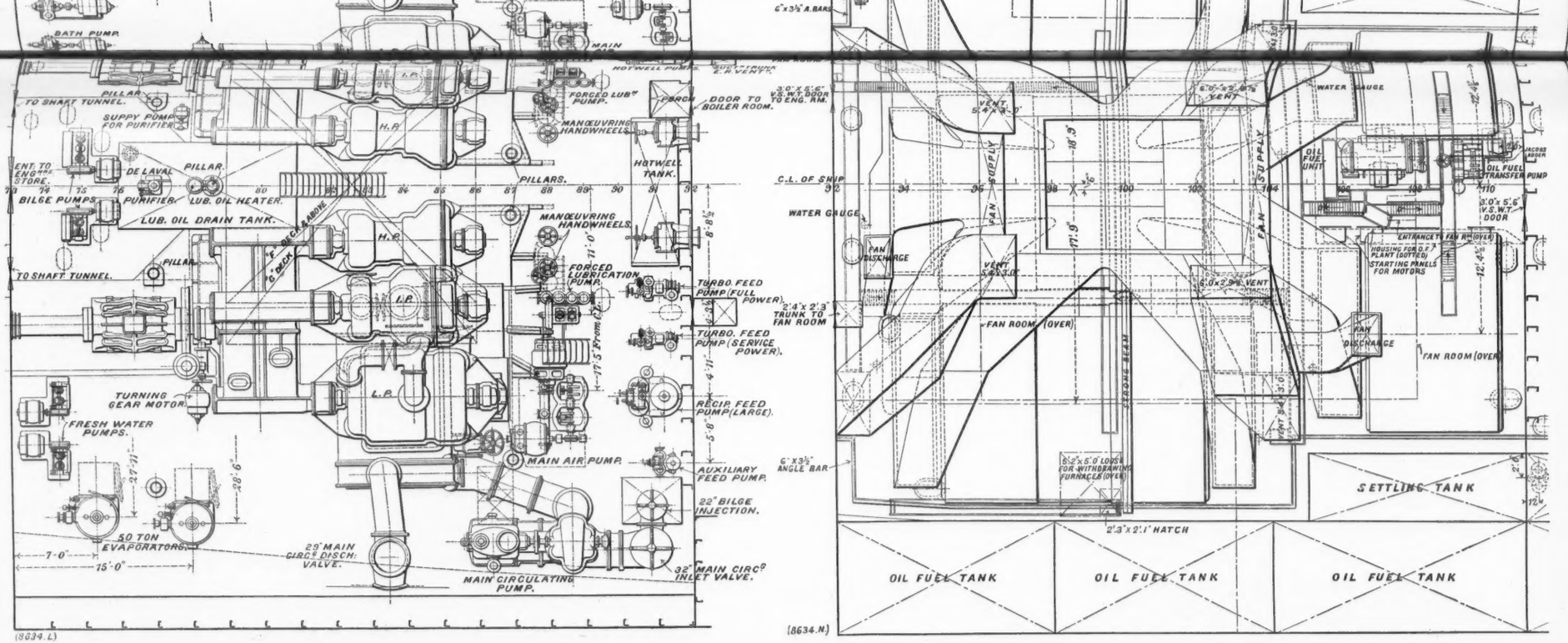


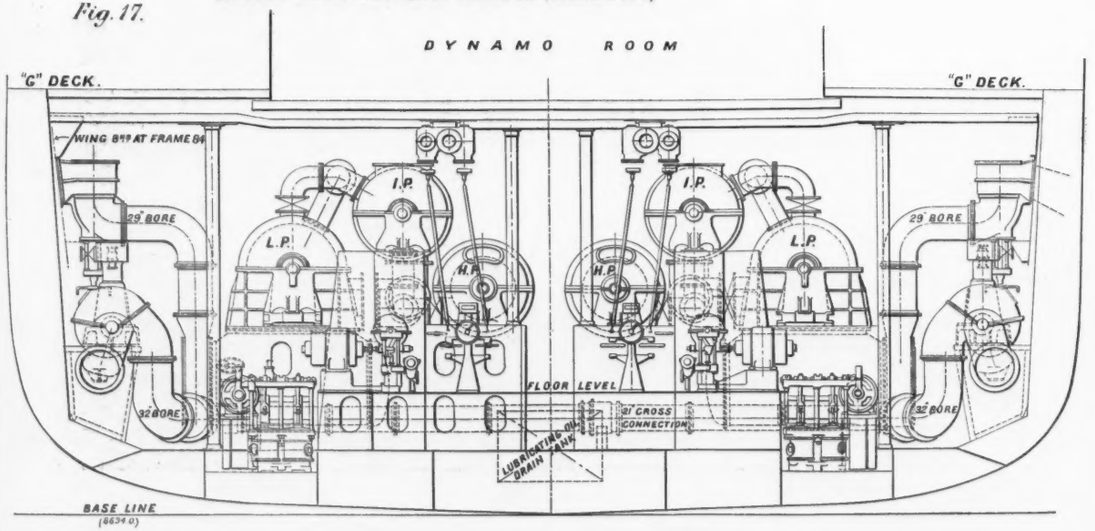
Fig. 20. BOILER ROOMS.





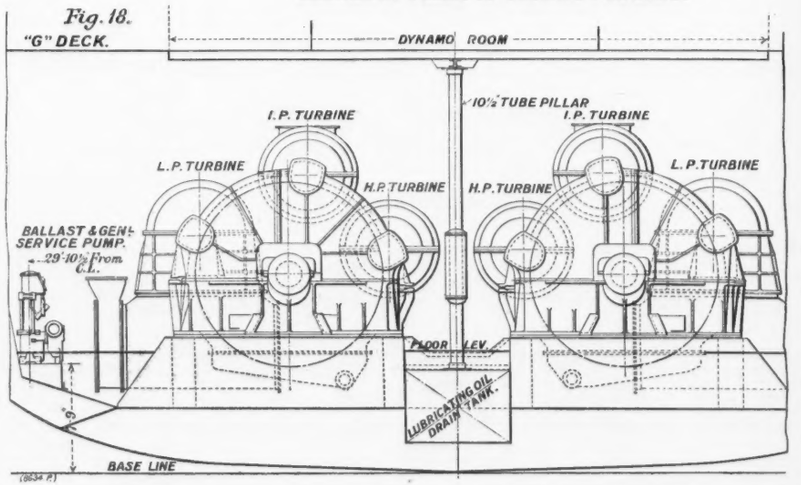
ENGINE ROOM. SECTION AT FRAME 89. (LOOKING AFT)

Fig. 17.



SECTION AT FRAME 78–LOOKING FORWARD.

Fig. 18.



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(*For Description, see Page* 601.)

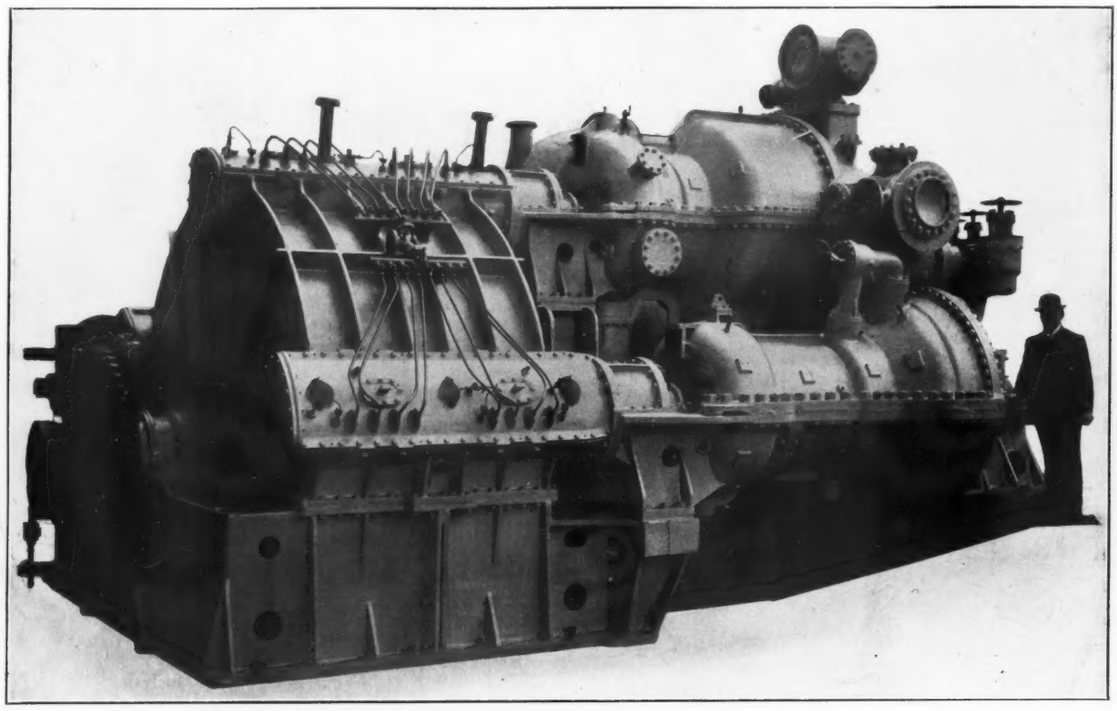

Fig. 21. View of Turbine Set from Gear Box End, Showing Oil Services.

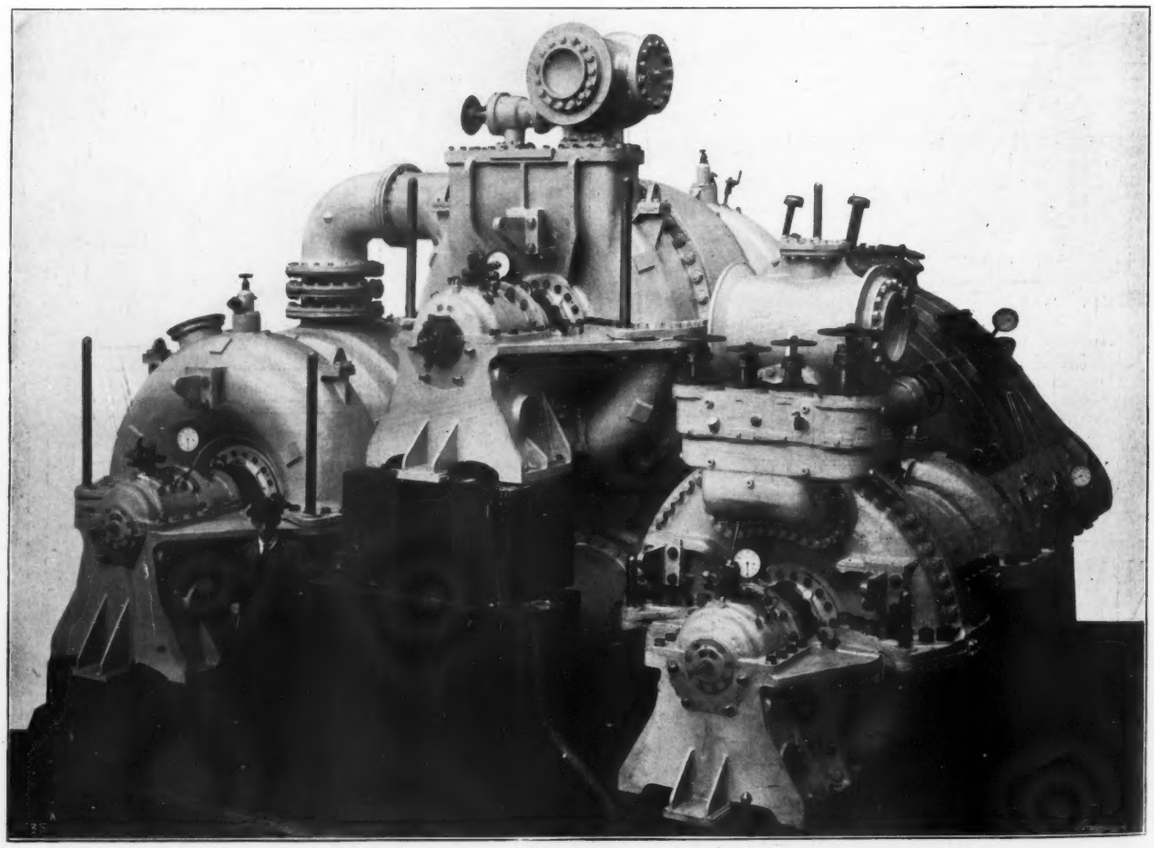

Fig. 22. General View of Turbine Set from Forward End.

(*To face page* 601.)

ENGINEERING.

Offices for Publication and Advertisements, 35 and 36, Bedford Street, Strand, London, W.C.2.

We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

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TELEPHONE NUMBERS—3663 and 8598 GERRARD.

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TIME FOR RECEIPT OF ADVERTISEMENTS.

Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity of going to press early with a portion of the edition, alterations for standing advertisements should be received 10 days previous to the day of publication.

All accounts are payable to "ENGINEERING," LTD. Cheques should be crossed "The National Provincial Bank, Limited, Charing Cross Branch." Post Office Orders should be made payable at Bedford Street, Strand, W.C.2.

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TASMANIA: Gordon & Gotch Prop'ty, Ltd., Launceston: Hobart.

UNITED STATES: For Subscription, New York: W. H. Wiley, 440, Fourth Avenue. For Advertisements: J. S. Allan, 30, Church Street, New York.

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One Two-Page Plate and Two One-Page Plates.—*MACHINERY OF THE TWIN-SCREW ORIENT LINER "ORAMA."*

ENGINEERING.

FRIDAY, OCTOBER 31, 1924.

REFLECTIONS ON THE BRITISH EMPIRE EXHIBITION.

THE three purposes for which the British Empire Exhibition was intended, were to display in the Motherland the resources of the Empire, to indicate to its Dominions and Colonies the present state of the Motherland's productions, and above all to improve the acquaintance of each part of the Empire with the others. The effects of an exhibition can seldom be judged by its immediate results, but the intercourse between exhibitors and visitors will usually give an indication of whether the ultimate outcome will be what was desired. So far as such indications may be accepted as trustworthy, the present Exhibition appears to have fulfilled each of its purposes. A certain amount of business in each direction has materialised, as a rule exceeding what had been anticipated, and prospects have been opened of still greater amounts in future. The inhabitants of this country and their fellow citizens from all parts of the Empire have cultivated a mutual acquaintance on a scale for which hitherto there has been no precedent. They seem not only to have got to know each other, but to have fallen into step with each other. They have been able to learn more than they ever knew, not only of such differences as exist between the habits of thought, feeling, and action of their respective homes, but also of the vastly greater respects in which these habits are common to all British communities. Far away from their homes, they have in a word found themselves at home.

The numerous Conferences that have been organised have added largely to the volume of information collected within the Exhibition, and have been the occasion of forming and cementing acquaintanceships and friendships, of which the best results lie doubtless in the future. The weather, indeed, has been the one arrangement that the Exhibition authorities have been unable to control. It is very difficult to estimate the extent to which this summer's deplorable weather has injured the attendance at the Exhibition and the volume of enjoyment it should have provided. If its effects be taken in context with those of the present unfortunate condition of trade and the political distractions that have occurred while the Exhibition was running, it could hardly be an extravagant estimate to say that the attendance at the Exhibition has been probably not much more than half what might have been expected in ordinary times, and during a summer that was no worse than the average in this country.

So far as concerns the exhibits, the Palaces and Pavilions of all countries have displayed the resources of the Empire as they have never been displayed before. The admirable and typical exhibits in the Palaces of Engineering and Industry have illustrated the comprehensive scale and variety of the manufactures that this country can supply, and the excellence of their quality. The exhibits of the Overseas Pavilions have illustrated not less effectively the variety of the products of the countries they represent, the fortunate circumstances of their climates, and the vast openings to be found within them for all the population and capital this country can spare. They have shown markets for our products that for any immediate prospect are unlimited, outlets for the energy of those among our fellow countrymen who seek wider scope and ampler opportunities than they can find at home, and illimitable resources in the Overseas Empire, which could be combined with our own facilities, organisation, and genius for manufacture. We have known much of this before; but now we have seen it and can realise far better how such a combination holds within it the possibilities of a self-contained and self-supporting Empire, within which the products and the labour that each country is best fitted to give could be mutually exchanged. Our visitors from overseas have learned more than they knew before of what can be made for them in this country, and trade as well as individual consumers in this country have begun to realise how many more products the Empire can supply, and how much more of them than had been imagined previously. A great step has, in fact, been made towards exhibiting the directions in which judicious arrangements could extend mutual trade within the Empire, at once fertilising great territories in it by co-operation from home, and widening the circle of customers for our own manufactures with greater Britain itself. As Sir Sefton Brancker pointed out at a dinner organised and attended by the exhibitors in the Palace of Engineering, which was held at the Hotel Cecil on Tuesday evening, our manufactures may have done much good by getting in touch with a greatly extended circle of buyers, even if they made no direct sales as an immediate result of the Exhibition.

The close of the Exhibition extinguishes, for the time being, a focus of social life. Visitors have frequented it from all parts of the Kingdom, the Empire, and indeed of the civilised world; but however assiduous their attendance has been, it is unlikely that any of them have exhausted the vast stores of interest and information that the Exhibition has provided, and many will regret that they had not a longer time for cultivating its acquaintance. We have ourselves endeavoured to give an adequate account of its contents, and a considerable staff of contributors have been engaged in studying it. Their published reports, if they had been printed together, would have filled sixteen full numbers of this journal, and the illustrations alone have exceeded one thousand. Yet even this share of our space has been insufficient to allow us to describe in the fullness we should have wished all the contents of the Exhibition that deserved attention. Had it lasted for twice as long, it would have continued to yield matter of interest to our readers; and the situation of visitors who have not had the advantage of studying it by teams must have been correspondingly worse.

The Exhibition, though it has not realised the financial success that had been hoped, has done much more in that respect than might have been expected. Probably no Exhibition of comparable scope in any country, at least since 1851, has ever gone so far towards covering its expenses, nor has worked under so heavy a burden of disadvantages. The yield that was asked of it, though the event seems to show that it would actually have been realised in more favourable conditions, is, after all, ridiculously high to expect of any business

enterprise. It amounted in fact to demanding that in six months' trading it should repay not only the expenses of working, but the entire capital sunk in it, although a large part was expressly laid out for permanent uses. Though it may be regretted that it has failed to accomplish what would have been almost an unprecedented performance, the result even from a financial standpoint must be regarded as highly encouraging. It shows that if the working of the present half-year were supplemented by that of another half-year, even a much smaller attendance than that of this year would be enough both to cover the whole running expenses and to replace the capital.

Whether the Exhibition will be resumed next year is as yet undecided, but in any event the results that it has given suggest that the Empire would be the poorer if the Exhibition disappeared permanently. There seems to be little doubt that the buildings could be filled next year with exhibits; but whether as representative of all parts of the Empire, as they have been this year, could probably not be stated without further enquiry. The general feeling among those who have taken part in it may possibly turn out on the whole to be in favour of continuing the Exhibition during next year; but a more general and perhaps a more important question is what use is to be made of it in a more extended future. Whatever may be held to be the exceptional circumstances that, in the opinion of many competent judges, recommend its renewal next year, the Exhibition cannot hope to be permanently successful as an annual exhibition. What, however, does not seem to be impossible is that like the Imperial Conference, it should become a periodical event. When the results of the last six months are considered and the prospects of the years that are ahead, it may well be thought that such an exhibition, once in each four or each five years, might be within the resources of the constituent states. Such an institution would help to maintain the personal touch between British citizens on the scale that the Exhibition now closing has initiated. No improvement in wireless communications could do as much to promote a healthy circulation of knowledge, feelings and purposes throughout the Empire. It would be the complement among its populations of the Imperial Conference of its statesmen.

MOTOR FUELS.

The popularity of automobiles has encouraged and helped the engineer to attack and to solve so many problems that the chief difficulties he has now to face are connected with thermodynamical problems of fundamental character. He knows that the constants upon which he has to base his calculations are not applicable to the temperatures and pressures with which he is dealing, and that the determinations of the instantaneous temperatures are indirect and uncertain. The maximum power that a type of fuel will give in an internal combustion engine depends upon the heat of combustion per unit volume of combustible gas, upon the change in the number of molecules on combustion and upon the specific heats of the resulting gases, chiefly nitrogen carbon dioxide and water vapour. For some time engineers were satisfied, and had to be satisfied, with specific heat values up to 1,500 deg. C. But the maximum temperatures of exploding gas mixtures certainly lie much higher, and the specific heats increase rapidly at higher temperatures. The researches, notably of Pier and Bjerrum in Nernst's laboratory, supplied those data for temperatures up to 3,000 deg. C., and pressures of 100 atmospheres, and their specific heats were true specific heats, making allowance for dissociation. But the efficiency calculations involved the assumption that all diatomic gases, have the same specific heat as nitrogen, and that nitrogen merely acts as a diluent in explosions—a point to which we shall revert—and further researches are desirable.

Dissociation must be taken into consideration because it increases the number of molecules. Dissociation may account for the peculiar fact that, in experiments with different mixture-strengths of the same fuel, the maximum power is attained when this strength is slightly higher than that corresponding to complete combustion, and that, with an excess of fuel, the power may not be diminished until the excess reaches 30 per cent. or even more. Heat of combustion per unit volume must not be confounded with heat of combustion per unit weight (or calorific value). If we class the common motor fuels as paraffins (hexane $C_6 H_{14}$ and higher homologues of the methane hydrocarbon series), aromatic hydrocarbons (benzene $C_6 H_6$ &c.) naphthenes (cyclohexane $C_6 H_{12}$) and ethyl alcohol ($C_2 H_5 OH$), we find that the calorific value is about 10 per cent. lower for the aromatics than for the paraffins, and for alcohol only two-thirds of the benzene value; yet the heat of combustion is within a few per cent. constant for all the hydrocarbons, and only slightly lower for alcohol. After combustion the working fluid is in all the cases practically the same, a mixture of CO_2 and H_2O, though in different proportion, together with inert nitrogen. The maximum power obtainable should, therefore, be proportional to the product of two factors, the heat per unit volume and the volume-ratio before and after combustion, and these products again are of almost constant value, differing by not more than 3 per cent. We have further to consider volumetric efficiency, or charge weight in the cylinder which depends upon the latent heat of evaporation of fuel. When this is done, the first three fuel classes mentioned again give almost identical maximum power figures, but the alcohol figure is higher, owing to its high latent heat.

The small differences between the various fuels and the complexity of the phenomena become much enhanced in the internal-combustion engine, because the motor fuel is not—and cannot be for various reasons—a pure chemical compound, but is a mixture of compounds whose composition changes during the working of the motor. In view of this complexity, the Empire Motor Fuels Committee of the Institution of Automobile Engineers has expanded its recent Report into what may almost be called a thermodynamical treatise. The report proper is restricted to tests on alcohols; but the volume embodies an account of the joint theoretical work by Mr. H. T. Tizard and Mr. D. R. Pye on "The Character of Various Fuels for Internal-Combustion Engines," which formed the basis for the investigation subsequently carried out by Mr. H. R. Ricardo (on behalf of the Asiatic Petroleum Company) on "The Influence of Various Fuels on the Performance of Internal-Combustion Engines," and there are further contributions.

Messrs. Tizard and Pye conclude that, starting from available data as to true specific heats and temperature equilibria, it is possible to calculate the temperature at each point of the cycle, and that the maximum powers to be expected from a paraffin and from an aromatic fuel are not appreciably different when compared at a compression ratio which allows full ignition advance without detonation. But higher compression ratios can more safely be used with aromatics than with paraffins, and thermodynamically very high compression ratios are advantageous. These and other conclusions are confirmed by the systematic series of tests which Mr. Ricardo conducted with his variable compression engine (illustrated in our issues of September 3 and 10, 1920) and with various types of engines and motor-cars. The freedom of a fuel from detonation is found to be the outstanding factor determining its value. When an explosive mixture is highly compressed at a temperature approaching that of its spontaneous ignition-point and is then ignited, the flame at first spreads by normal combustion and compresses the unburnt portion of the charge before it. When the rise of temperature in that portion exceeds the rate of heat dissipation, spontaneous ignition takes place and an explosion wave is set up which, striking the cylinder wall, causes the metallic ring known as pinking or detonation. Persistent detonation may raise the plug temperature sufficiently to cause pre-ignition.

Mr. Ricardo now takes the point at which detonation becomes audible with both ignition and mixture strength adjusted to give the highest efficiency, as representing the highest useful compression-ratio for any fuel—not the highest ratio that can be employed, but the highest that it is worth while to employ. Disregard of that condition he considers would largely explain why certain fuels appear to give greater efficiency than others in the same engine. Most engines being run at too high a compression for the ordinary brands of petrol, he submits, have to operate with too far retarded an ignition and too rich a mixture. By changing over then to another fuel of a higher detonation point the ignition timing may be advanced and the mixture strength be corrected with gain in power and economy. But if the same brands had been tried in an engine with a lower compression ratio, no efficiency difference would have been observed, and Mr. Ricardo shows further that, using compression ratios for the most efficient mixture strength and ignition timing, all fuels have substantially the same efficiency and, complete evaporation of the liquid fuel before its entry to the cylinder presupposed, all fuels give substantially the same power output.

Broadly speaking, the temperature of spontaneous ignition is a measure of the tendency to detonate; but there is no rule. Carbon disulphide, while readily pre-igniting, will not detonate, and with similar fuels the pre-ignition point is very difficult to determine, as the point depends upon the temperature of the exhaust valves, the sparking plugs and other parts. In general, the tendency to detonation appears to be the smaller, the lower the rate of burning, and a low rate of burning to be advantageous. Mr. Ricardo did not find any fuel of a too low a rate of burning to permit of maximum efficiency being obtained in the highest-speed engines yet tested. The highest useful compression ratio would depend upon the relative proportions of aromatics, naphthenes and paraffins; the proportion of paraffins should be small, from every point of view. Olefines have not yet been investigated.

Alcohol was the subject of special tests by the committee, and was investigated in strengths of 95 per cent., 90 and 99 per cent., and also in mixtures with ether. The efficiency obtained with alcohol at a compression ratio of 3·8 : 1 was substantially greater than that with petrol, and the heat delivered to the jacket water was lower in the former case. There was no indication whatever that alcohol required a high compression or was unsuitable for high speeds at low compression; at a ratio of 7 : 1 and speeds exceeding 1,700 r.p.m., pre-ignition occurred occasionally, but there was no sign of detonation. Even at this highest compression the engine ran more smoothly on alcohol (of 95 per cent.) than on petrol; there was no detonation, but any pre-ignition observed after prolonged run at 1,675 r.p.m. was of extremely violent nature. As regards the concentration (99 and 90 per cent.) a high water content seemed to be of little or no disadvantage, and the prevalent idea that alcohol required a great deal of preheating is rejected; preheating was needed only to correct errors in distribution. The report justifies the addition to the alcohol of ether (10 to 15 per cent.) on the grounds of better performance at reduced loads; furthermore, the addition would lower the temperature at which starting is possible.

The phenomena of detonation and its prevention have been much investigated during the past two years, chiefly by Mr. T. Midgley, of the General Motor Research Corporation, of Dayton, Ohio, to whom the American Chemical Society last year awarded the Nichols medal for this work. While bromine and oxygen (also in certain compounds) promote detonation, benzene and still more toluene and absolute alcohol counteract it. As only the strongest alcohol is miscible with petrol, alcohol cannot serve as an "anti-knock" substance. But iodine, aniline and particularly the ethyl compounds of selenium, tellurium, tin and lead are extraordinarily efficient as such. Lead tetraethyl will suppress detonation when present in a concentration of 1 in 215,000. The nature of the effect is for the present obscure. It has been suggested that the substances become activated by absorbing radiations; but the concentration of the tetraethyl seems too minute for such an effect. It is interesting that the sudden demand for this compound quickly lowered its price from 100*l.* to 10*s.* per pound. Mr. Ricardo, who has made detonation one of his special studies—the subject is discussed in the report by

Dr. A. E. Dunstan and Mr. S. Card—considers that none of the "dopes" promise a real increase of power. The use of "ethyl gas" requires special ethylisers; the gas is poisonous, it deposits some grey-brown matter on the cylinder walls, and is apt to destroy the sparking plugs and to attack the lubricant. According to the advocates of tetra-ethyl, the harm done is small and curable by the addition of ethylene bromide.

In our introductory remarks we referred to the questionable inertness of nitrogen. The fixation of nitrogen is based upon its oxidation at high temperatures. Those temperatures occur in internal-combustion engines, and Häusser has attempted to utilise that oxidation of nitrogen in the internal-combustion engine. Some day the attempts may become successful. Meanwhile, Professor Bone has observed that nitrogen becomes activated and more readily oxidisable in explosions, especially at high pressures, but only in the presence of carbon monoxide. Nitrogen and carbon monoxide have both the same molecular weight 28, and Professor Bone suggests that some vibrations of the burning monoxide set up resonance vibrations in the nitrogen. Technically the observation has so far no interest; but it may prove to be one of the fruitful peculiarities upon which theory can base further research.

ELECTRICAL DEVELOPMENT.

It is presumably because of its youth that the electric supply industry has had to suffer to such a deplorable extent from legislative interference. Most other public services have in comparison been left fairly well alone. They were perhaps too well entrenched before the modern itch for meddling developed, and it was easier to attack the newcomer. The tradition, dating from the 'eighties, that electricity supply was fair game for the politician, has been consistently applied throughout the intervening years, and even in the last few weeks it has been threatened with fresh legislation. The latest idea appears to be that by further disturbing the electrical business one will in some mysterious way solve all our economic and social problems. As Mr. W. B. Woodhouse said in the presidential address which he delivered to the Institution of Electrical Engineers on Thursday of last week—"Electricity supply is a beneficial and useful service to the community, but it is unwise and misleading to suggest that its artificial stimulus will prove a solution for all our industrial ills."

The main portion of Mr. Woodhouse's address was devoted to a sketch of the development of the electrical supply industry in this country. What he had to say may be read with interest and profit by all electrical men, but if we may venture a criticism it is that he struck a somewhat too apologetic note throughout. His address appeared to us rather too much an explanation of why in electricity supply this country is so much behind some others. The reasons given were the legislative interference to which we have already referred, the effect of cheap coal, the high cost of distribution and so on. Weight must be given to all these factors and the analysis of the position given by Mr. Woodhouse is of much value, but we would have wished a President of the Institution of Electrical Engineers to enlarge on the means which were, and could be, taken to surmount handicaps, rather than to lay stress on such handicaps as an explanation of our moderate progress.

Having made our protest it is but fair to examine Mr. Woodhouse's explanations and apologies, all of which appear to us to be, within their limits, very sound. Of these, one of the more important is the cost of services, particularly for domestic supply. Mr. Woodhouse stated that while no general statistics are available, it was probable that less than 20 per cent. of the houses in this country were wired and connected to the public supply. This figure appears reasonable, and we should think is certainly not overstated. A further point is that, in general, the houses which can be most cheaply supplied have been dealt with first, so that on the average the remaining 80 per cent. of houses will cost more to wire and connect. In this connection some very interesting figures taken from the 1921 Census were quoted by Mr. Woodhouse. It appears that in London 45 per cent. of dwelling-houses contain less than six rooms, and that the corresponding figure for Manchester is 77 per cent., and for the West Riding of Yorkshire 82 per cent. It is a fair assumption that the majority of existing consumers of electricity dwell in houses containing more than six rooms, so that the connecting of the remaining 80 per cent. of houses is likely to be, on the average, a more difficult problem economically than has been the present 20 per cent. which is taking a supply. The smaller house is potentially a smaller user of electricity, while the cost of distribution to it is practically as great as to the larger house.

There is a further point bearing on this matter to which, however, Mr. Woodhouse did not refer in any detail. This is the competition with gas for the domestic load. This competition is of particular importance from the point of view of the cost of house wiring. There are enormous sums invested in gas pipes laid in houses, and in gas fittings which if not technically part of the capital of the gas supplies, are in effect part of such capital, and when any house changes over from gas to electric light part of this capital has to be written off. It is, however, not written off by the electric supply authority, but by the house owner, so that it forms a handicap against which the electric light concern has to contend. Matters of this kind all have had effect in keeping the kilowatt consumption per head in this country considerably below that in some others. We are, of course, concerning ourselves here only with domestic consumption, but this is an important item in the total, and has much to do with some of the very high figures achieved in some American towns.

It, however, hardly seems satisfactory from an electric supply point of view to point out these various handicaps and difficulties and leave the matter at that. If, as Mr. Woodhouse states, the cost of the distribution of electricity for lighting adds 300 per cent. to the cost of production, it would appear that it would be worth some considerable effort to cut down the cost of distribution. One method of doing this would appear to be in a much more extended use of overhead networks, not only for main but for secondary distribution. There is no need to go to the Continent to see quite satisfactory overhead networks supplying small towns. There are plenty of cases in Great Britain. There does not, however, appear to be any very serious effort on the part of supply authorities to extend the system to any considerable extent, but it might be used quite largely. We would hardly recommend it in Bond-street, but see no objection to it in many of the new residential areas being developed in the neighbourhood of our large towns. It is sometimes said to be unsightly, but we are unable to see that it is as unsightly as some of the overhead erections of the Post Office, which are taken as a matter of course.

Apart from this question of overhead distribution, one cannot always think that our average electric supply authority is quite as enterprising as it might be in connection with the domestic load. Once a main is laid down a street it would appear reasonable to take considerable trouble and even to spend some money to get as many houses connected to it as possible, but one in general does not find supply authorities dealing with matters of this kind with an energy corresponding to that of the gas companies. Further, although electric light supplies are not likely to make much profit from doing business at a loss, one sometimes wonders if they do not play too safe, and if more attractive terms might not very quickly lead to considerably extended business and greater total profits. Before the war, there was an admirably energetic association calling itself the "point fives" the purpose of which was to press for domestic supplies at ½d. a unit. One trusts that the point of view of this association has not been lost.

We have dealt at some length with the domestic load because it appears the most likely sphere for considerable extensions in the reasonably immediate future. The power load is more dependent on the general trade of the country, while it is probable that isolated steam plants are being superseded by power taken from distributing mains as quickly as can be expected. As Mr. Woodhouse pointed out, there is not the same incentive towards central power generation in a country where coal is cheap and easily obtained as in one where it is scarce and dear. It must be remembered, however, that some of the heaviest electric supplies per head of population in other countries are being taken from coal stations, and that we cannot merely explain away our backward position by talking about water power. The matter is partly one of some conservatism on the part of possible customers, and is partly due to large numbers of old established factories in this country as compared with some of the more recently developed modern areas which show such a heavy consumption. An example of this kind of effect is afforded by the textile mills of Lancashire. Were the majority of these electrically driven one might see the load factors of some of the Lancashire supply systems approaching the 49 per cent. of Shanghai, which has a large textile load supplied, one imagines, to mills, many of which have never had the independent steam plant which is characteristic of the Lancashire mill.

The effect of unwise legislation in hampering the development of electric supply, we have already referred to. We need not enlarge on the matter further now, but in quoting and endorsing Mr. Woodhouse's statement, that the whole industry has great admiration for the work done by the Electricity Commissioners in most difficult circumstances, we would add our prayer that they may be left alone by our legislators, and that a harassed industry should be given a long close season free from any governmental interference.

OVERSEAS TRADE AND UNEMPLOYMENT.

After such an upheaval as was occasioned by the European War it was natural that there should remain for solution many problems concerning national financial stability, the provision of employment for the millions of workers and the gradual winning back of the position of national supremacy in trade. These are not problems in which the financial people are solely interested, for the effects are experienced by men in every class of the community, and they desire to know something of what has caused the complete dislocation of industries with which they are concerned. Engineering institutions generally have done little to interest their members in matters of this type, although the well-being of all must be determined by their effective solution. It is, therefore, a matter for congratulation that the Institution of Civil Engineers decided to arrange for the address on "The Economic Position of Great Britain," which was delivered by Mr. Edgar Crammond on Tuesday last.

In presenting his address, Mr. Crammond referred to the intensive economic development which took place between 1870 and 1914, during which period the world became merged into one great economic unit with London as its centre. With the great growth of international trade and the enormous increase of wealth in all parts of the world, Britain was enabled to accumulate immense reserves of economic strength. Then came the war and the strength of the financial policy of Great Britain was manifested to the world. To-day, although the financial position of the country shows the characteristics of unchanged confidence, there are problems which still await solution, such as the great evil of unemployment. Under the prevailing conditions, when British trade is only maintained with great difficulty against the competition of those countries where the wages and labour conditions are such that they can produce much more cheaply, it is to be expected that some people see reasons for a belief in the industrial decline of Great Britain. That pessimistic view, however, is not warranted by the conditions. At the present time we are passing through the greatest crisis in industry we have ever experienced. This is due to the economic collapse of Central Europe and Russia, the depreciated currencies of many countries with which formerly we had intimate trading relations and the obstacles

to the freedom of trade, which had resulted from the creation of a number of small states under the Treaty of Versailles, each of which meant more frontiers, tariffs and customs troubles. The blockade during the war had the effect of stimulating a desire of all countries to become more self-supporting and thus more independent of imported produce and manufactures.

What steps are necessary then to remove the curse of unemployment which these changes have occasioned? The essential requirement is the increase of the national income. That can only be obtained through a great increase of material production. Unfortunately, this must be obtained when our industrialists are carrying a crushing burden of taxation, and at the same time are called upon to meet demands for scales of wages and reductions of working hours which make it impossible for them to compete successfully with some of the other great industrial countries. Until the volume of international trade is restored to the level of pre-war days, it is necessary that everything possible should be done to increase the national income so that the manufacturers may carry the burden put upon them by labour and by taxation. Mr. Crammond suggested that the most effective step which could be taken and which was immediately practicable, was to increase our investments abroad. By this expedient before the war, we were enabled to increase our exports and maintain an equilibrium between our manufacturing production, our income from shipping and our services in international trade and finance. In 1913, we invested abroad about 200,000,000*l.* allowing for rises in prices, this sum represents 320,000,000*l.* to-day, but in 1923 investments abroad only amounted to 130,000,000*l.* Were it possible to bring up our overseas investments to the 1913 level, the national income would be increased, Mr. Crammond thought, by something between 200,000,000*l.* and 300,000,000*l.* per annum, and employment could be found for many of the men who are idle at present. At the same time, this would create conditions which would enable an additional 50,000 persons to emigrate each year, with the certainty that they would find remunerative employment overseas.

The real fund out of which capital was provided for investment abroad was, he said, the excess of production of foodstuffs, raw materials and manufactured goods over consumption. Improvement was possible, as we were working at 75 to 80 per cent. of our capacity and had over 1,200,000 unemployed, in addition to which there was a large number of partially employed persons. The great bulk of the proposed additional investment would be provided by the utilisation of British labour, raw materials and manufacturing equipment. For the purpose of this scheme, we should probably have to increase our imports of raw materials and manufactures to the extent of between 60,000,000*l.* and 80,000,000*l.* a year. There was a belief that there were not solvent purchasers of our manufactures to the extent suggested. This difficulty was not insuperable. There was a surplus population in Great Britain, available for emigration at the rate of 250,000 per annum, and if this outflow of British people and capital were directed to those portions of the Empire that could produce the foodstuffs and raw materials we needed, it was certain that it would bring about such an increase of wealth and productivity in the Empire that the products of British labour at home could be safely absorbed to the extent indicated. It was not extravagant, Mr. Crammond thought, to estimate that the adoption of this policy would add about five million to the white population of the overseas Empire, beyond the normal increase, within the next twenty years. The addition to the wealth of the Empire during the same period, beyond the ordinary growth, would be not less than 5,000,000,000*l.*

It is obvious that, as the funds available for meeting depreciations of capital and for new investments are obtained from the savings left after all living expenses are met, the way to obtain funds for investment abroad is by individual and national economy. What signs there are of the reduction of expenses may be judged from the figures for national expenditure in, say, 1907, and 1923 for which figures are available. In 1907, the expense of the national services was met by the use of 8·5 per cent. of our total income, to-day that figure has increased to 19·4 per cent. The manner in which this phenomenal increase in taxation is hindering the return of unemployed men to work may be judged from the fact that, apart from comparatively small increases in the percentages of total income expended on food, dress and house-rent, the whole of this increase in taxation is drawn from funds that would otherwise be available to maintain capital and for new investments in industries providing more employment and creating further wealth.

NOTES.

The Rensselaer Polytechnic Institute.

The 100th anniversary of the founding of the Rensselaer Polytechnic Institute, Troy, New York, U.S.A., was celebrated on October 3 and 4 last, the proceedings being attended by a number of eminent engineers and leading educationalists. Amongst the distinguished non-Americans present were the President of the Institution of Civil Engineers, the President of the French Society of Electrical Engineers, the President of the Italian Society of Civil Engineers, and the President of the Engineering Institute of Canada. The Rensselaer Polytechnic Institute was founded in 1824 by Stephen Van Rensselaer, so that it is nearly the oldest technological college in English-speaking countries, being probably ante-dated only by the Royal Technical College, Glasgow, which dates from 1796. At the time of its foundation American colleges for higher education still held fast to the classical tradition, little or no provision being made for a broader culture. Dissatisfaction with this condition of affairs had given rise to protest, and a number of schools of different grades were established in the first quarter of the last century with the object of filling the need. Of these the sole survivor has been the Rensselaer Polytechnic Institute. In the century of its existence between 6,000 and 7,000 students have taken the courses there provided. The first class in civil engineering was established in 1835, and rapidly grew in influence and importance, and courses for mining and mechanical engineering were provided for in the 'sixties but were abolished in 1871. It was not, in fact, till 1907 that the courses in mechanical and electrical engineering were placed on a permanent footing. A course in chemical engineering was added in 1913.

A Proposed Change in the Bow Construction of Ships.

There are many different types of accidents which a ship may encounter at sea, and progress in naval architecture may be measured by the degree of success of any new device and method of construction in preventing their occurrence or making their effects less dangerous to the ship, its passengers and its cargo. For long, designers have been engaged in studying methods of reducing the risks when vessels run into each other, into rock faces or icebergs. Damage to the hull under such conditions may be regarded as an absolute certainty, and the subdivision of the vessel must be looked to for the saving of the ship, if it is at all possible. With the intention of limiting the damage done to a rammed ship and also to the one inflicting the injury, Mr. E. J. Spanner has designed a type of bow which is less rigid than the normal construction. The intention of this method of building is to confine the damage of the ramming vessel to the portion of the bow forward of the collision bulkhead and keep the rest of the ship in a watertight condition. This form of design has been submitted to the consideration of the members of the Institution of Engineers and Shipbuilders in Scotland, in a paper entitled "A Proposed Form of Bow Construction," which was read on October 28 by Mr. Spanner. The suggestion is to make the plating at the bow on vertical, instead of longitudinal, strakes and replace the normal stem bow by a dished plate, which would generally be of 6-in. radius. It is claimed for this construction that it prevents the possibility of causing an intense local stress anywhere in the shell of the rammed ship. Another claim is that the construction, although it will withstand minor blows without much damage to the bow, when the action is severe no great forces will operate on the collision bulkhead, as the material is arranged so that its distortion and rupture will be capable of absorbing the greater part of the energy expended in the collision.

Waters for Concrete Mixing.

An elaborate investigation carried out by Professor D. A. Abrams in the Structural Materials Research Laboratory, of the Lewis Institute, Chicago, has led to the welcome conclusion that almost any water will serve for mixing concrete. Full particulars of the tests are given in a Bulletin published by the laboratory, where, presumably, copies can be obtained by those interested. The principal criterion used to gauge the suitability of a water was, that in a 28-day test, the sample mixed with the impure water should not have less than 85 per cent. of the strength of comparison specimens mixed with fresh water. Sixty-eight different samples of water were used in the research. Amongst them were sea and alkaline waters, bog waters, mine and mineral waters, waters contaminated with sewage and industrial wastes, and also solutions of common salt. All the specimens were mortar or concrete mixtures, neat cement tests being excluded. The waters found to yield concrete with less than 85 per cent. of the normal strength, were acid waters, lime soap from furriers, refuse from a paint factory, mineral water from Colorado, and waters containing more than 5 per cent. of common salt. This latter result is important, and Professor Abrams draws the inference that the use of salt for lowering the freezing point of water used for mixing concrete in cold weather should not be permitted. Five per cent. of salt in water lowers the freezing point by about 6 deg. F., but concrete mixed with such a solution has a strength 30 per cent. below normal. Observations made on the setting time showed that in general this was much the same with pure and impure waters, but there were some notable exceptions. In most cases, specimens giving low strength ratios were slow setting, but the experiments indicated that the time of setting was not a satisfactory criterion for judging the suitability of a water for mixing concrete. Most specifications, Professor Adams observes, would, if strictly enforced, exclude all waters but rain-water or distilled water, but the tests have shown conclusively that almost any impurity may be present without necessarily producing ill effects. The important point is not whether impurities are present, but whether they occur in injurious quantities. Previous experiments, it may be added, have shown that the addition of sugar and similar bodies to the mixing water is most injurious, so that it was thought unnecessary to include sugar solutions in this investigation.

LITERATURE.

Reinforced Concrete Design. By G. P. Manning, B.Eng. (Hons.) Assoc.M.Inst.C.E., Mappin Medalist in Engineering of the University of Sheffield (1913). London: Longmans, Green and Co. [Price 21*s.* net.]

With the rapid development of reinforced concrete since its introduction, as a recognised form of construction, into this country in the late 'nineties of last century, and the special attention given to its design by engineering students, it is only natural that a literature should arise devoted entirely to this branch of engineering. Amongst the many books published during recent years on the subject of reinforced concrete design, Mr. Manning's volume takes a high place, owing to its general excellence and comprehensive character. Some of the author's opinions and conclusions are doubtless open to argument, but a book such as he has produced is none the less valuable in that it contains contentious matter, giving food for thought in many directions. The practising engineer will be able to form his own conclusions on debatable points, while the student will be guided by those in authority, and his studies of the subject will not be confined to Mr. Manning's treatise. Nevertheless, it is to be regretted that the author should so frequently advocate the use of different factors for "standard" and "competitive" design. In a book such as that produced

by Mr. Manning, one does not expect to find the designer advised to use higher values for safe resistances and thinner concrete coverings than those generally recognised, when the structure will be the subject of competitive prices.

The "standard" allowances are either right or wrong. If, in the author's opinion, they are wrong he would be justified in demonstrating the nature and extent of their falsity, and in advocating the reconsideration of their values, but the recommendation of higher values for resistances, and lesser thicknesses of concrete coverings in the case of competition designs, without giving any logical reasons for such recommendations, is a disappointing feature in a book of the kind under review.

Mr. Manning has adopted the excellent practice of giving worked-out examples, showing the application of the various formulæ, diagrams and tables. These will prove of the greatest assistance to those using the book, either in the class-room or office. It is unfortunate, however, that the essential formulæ are in very few instances numbered, whilst the value of cross-referencing does not appear to have occurred to the author.

In the earlier chapters, dealing with the design of rectangular and T-beams under flexure, and members under direct compression and tension, the treatment is necessarily similar to that given by other authorities. The author, while giving the general equations for members subjected to flexure, confines his use of these to the case where the compressive and tensile resistances have both their permitted safe values.

The chapters on members under direct stress and flexure combined deal with rectangular, circular and annular sections, and useful diagrams are given to assist in the solution of problems arising in connection with structures subjected to these conditions when reinforced with bars of equal sectional area symmetrically arranged with a definite spacing. A chapter is also devoted to the subject of shear, analytical treatment for vertical and inclined bars being given, followed by a discussion upon the various methods of reinforcement and the spacing of the bars.

The author applies analytical treatment again to ideal continuous beams with an infinite number of spans, resulting in the derivation of tables and diagrams giving influence lines for moments at various supports and envelopes of maximum possible bending moments throughout inner and outer spans under various conditions of loading. The shears at the supports of continuous beams are derived in the usual way from the restraining moments.

Having dealt with the theoretical treatment, the author considers the practical utility of his analysis, and arrives at the conclusion that certain fixed values should be adopted for the bending moments at the various supports. Subsequent matter covers the preparation of quantities; the design of footing slabs and beams, methods of reinforcement and lay-out; design of bracings, ties, columns and struts, and the bending moments and shears on rectangular slabs. These are all given adequate consideration. A chapter is devoted to the analysis of long columns, and a diagram is given for the safe loading per square inch on square columns for various values of length, side and various percentages of total reinforcement.

In his treatment of arched members, the author assumes that the value of $d\,s \div E\,I\,d\,x$ is constant for any particular arch; $d\,s$ being a small length of the arc, and $d\,x$ the equivalent horizontal length, and he deduces general equations giving the values of the horizontal thrust, the vertical shear, and the bending moment at the centre of the arch for point loading, from which he obtains values of the bending moments at other points by assuming the load at various positions and the use of simple statics. He gives detailed analysis for parabolic, elliptic and circular fixed arches and for parabolic and circular arches hinged at the springings together with the deduction of the effects of temperature stresses. He also deals with square frames and box culverts treated as arches. Useful diagrams are provided, giving bending moment and horizontal thrust envelopes for parabolic fixed arches under uniformly distributed super-load, together with tables and diagrams for influence lines for bending moments and horizontal thrusts for fixed parabolic and elliptic arches under point loading and tables of bending moments and thrusts on these forms of arch, due to changes of temperature.

Chapters are devoted to Circular Tanks; Piling; Hopper Bottoms; Bunkers and Silos; Hollow Tile Flooring; Flat Slabs supported direct on Columns; Domes, Spires and Spherical Tank Bottoms; Staircases; Water Towers and Reservoirs and Retaining Walls. It is not possible here to discuss all these. In the treatment of circular tanks, consideration is given to the effect of the restraint induced by the rigid attachment of the bottom to the sides. The lay-outs for slab and beam floors are discussed, also various types of bridges. A special chapter is devoted to the treatment of continuous footings on yielding soils, and the author concludes with a dissertation upon the principles of design, setting out the general opinions he has formed upon various matters.

Mr. Manning has undoubtedly dealt very thoroughly with his subject, and his book can be confidently recommended to the attention of those interested in reinforced concrete design and construction.

Industrial Management. By Richard H. Lansburgh. New York: John Wiley and Sons, Inc. London: Chapman and Hall, Limited. [Price 22s. 6d. net.]

One of the most significant changes which has taken place in the world of manufacture during recent years is the result of the recognition that, if management is to be efficient, something more than technical knowledge is required. It has been demonstrated, in some instances in the bankruptcy court, that technical efficiency, essential as this undoubtedly is, does not ensure the successful running of a works, and consequently the need for administration has made itself felt. Administration is a broad term, which finds expression in organisation, and organisation is reflected mainly in the arrangements made in the preparation for, and the control of, production, and in ascertaining and comparing its cost.

This recognition of the importance of administration has been made articulate in the large number of books which have been written upon the subject, although the views expressed therein vary greatly. The great improvements in output and cost which have followed the introduction of efficient organisation have been so pronounced that there is a tendency for the true perspective to be lost, and some people appear to think that organisation itself is an aim. Broadly speaking, organisation is developed on one or both of two main lines (1) to control production, (2) to ascertain the cost of production; but it is not uncommon to find that attention is given to the latter while the former is neglected.

In his book "Industrial Management," Professor Lansburgh treats the question on broad if, in some instances, on somewhat hackneyed lines. He both opens and closes on the right note. In his opening paragraph he says, "Machinery and materials may be put to work, workers may labour; but without adequate management to guide their operations into profitable channels, to distribute the results of their work effectively, and to govern their operations during performance, this performance may become so uneconomic as to cease entirely." In the closing chapter entitled "Management Control Through Costs," the author says, further, "Though cost accounting forms the soundest groundwork for information on which magagement decisions may be based, and profits insured, like other business methods it is not an aim in itself. It is only of value in so far as it aids in operations and in the making of intelligent executive decisions which will promote the healthy advancement of the business."

In these two quotations is contained the keynote to successful works management; the effective control of methods and a check of the degree of efficiency secured as shown by the costs. Between these the author, after tracing briefly the history of industrial management, takes his readers through the various phases of the same, dealing with plant, buildings and lighting, standardisation, product and methods, time study, wage payment, employment of labour-selection, training and treatment, planning, &c. These are quite usefully discussed, many practical references being made to, and illustrations given of, works engaged in various industries in the United States.

As will be obvious, some of these subjects have been written upon so much that really new treatment is not easy to give; at the same time that given in "Industrial Management" is generally good, while there are certain portions of the book which deserve special attention. One of these is Chapter VIII, in which the effects of organisation on the "morale of the staff" are dealt with. One of the most deplorable results of the "organisation," in some works is the destruction of initiative amongst the staff, the line taken being that organisation can take the place of brains, obedience rather than initiative being required; in other words, the old autocracy of the one "superior" brain is being re-introduced. This brain suffocation lies at the bottom of the ineffectiveness of more than one scheme of reorganisation and, in some works, is a serious menace to success. Another useful section is Chapter XI, dealing with industrial lighting. Both natural and artificial lighting are dealt with, illustrations and useful data being given. Budgeting is also usefully discussed, a subject that justifies more attention than is now commonly given to it. If "bankers are going to demand the submission of a budget . . . . with substantiating figures, at the time that applications for loans is made," there will be some firms to whom, for this reason alone, the obtainment of a loan will present real difficulties.

In so far as such a large subject as industrial management can be treated satisfactorily within the covers of one book, the author has covered the subject fairly thoroughly. It is becoming open to question, however, whether, as with some other large subjects, general treatment will not have to give way to the more exhaustive and detailed treatment of the separate phases of administration. The superficialities of the subject are known in a more or less satisfactory manner to the vast number of people in industry, and the need is being felt for a closer and more detailed treatment than is possible in the more comprehensive works. The author takes the usual liberties of his country in the Americanisation of the spelling of our English words, and we note in passing a more than usually large number of split infinitives. The book is printed in easily-read type, on good paper, and, to a man requiring a book on this subject, will amply justify its purchase.

Ore Dressing: Principles and Practice. By Theodore Simons, Professor of Mining Engineering, School of Mines, University of Montana. London: McGraw-Hill Publishing Company, Limited. 1924. [Price, 17s. 6d.]

Too frequently it might be urged that the writers on technology are anxious to combine minute details of the latest practice with the description of the simple elementary principles that have guided pioneers and manufacturers in the production of elaborate apparatus, whose ingenuity and efficiency appeal to their matured experience. In the effort to produce a comprehensive work, there is little attempt to discriminate between the classes of readers to whom the book is presented. In this case, however, the author has a very clear view of the particular class he wishes to reach, and being gifted with the power of lucid explanation, he has produced a treatise whose purpose and treatment are well defined and praiseworthy. For the trained engineer, a knowledge of the principles that underlie the work of ore dressing, and actual familiarity with the practice and machinery in use, are both necessary, but it is only a knowledge of the general fundamental principles that can be acquired from text-books. No amount of information given in books will be sufficient to make a competent practical operator, and on the other hand, he who has acquired capacity and insight from mining practice will not need to consult a text-book. Therefore, the amount of purely practical information has been reduced to a reasonable minimum: no attempt is made to cover the endless details of operation that are always changing, and may be applicable only to the mill for which they were originally designed. But since the basic principles do not change with

time or locality, these have a lasting value, and the author concentrates his attention on them. This clear perception of the value, or limitation, of book knowledge does not make the treatise less practical. At a very early stage, Professor Simons indicates that the aim of the art of ore dressing is "to convert the given raw material into the greatest number of saleable products, and to do this at the least possible cost." Having set out this obvious principle, he never loses sight of it.

In pursuance of this plan, it will be understood that the author has given greater attention to the theory of mechanical construction than is usual in these works. On similar grounds, the machinery described is not necessarily the latest or that which is recommended as the most economical, but that which best exhibits the method of obtaining a desired result. The diagrams selected to illustrate the arrangement of the mechanism are clear and simple, and the details can be easily followed since they are unencumbered with those later elaborations that experience has suggested. We are not so convinced of the success attending the attempt to give a mathematical dress to the reasoning. The form may prove misleading by giving the appearance of a greater degree of accuracy or trustworthiness than is warranted. To give an example: the gravity process of concentration as explained here is put forcibly, and Rittinger's basic equation is derived in a very simple manner. The practical application is, however, not without difficulty and possibly without meaning, for as the solid particles decrease in size there must come a stage when the finest particles absolutely refuse to obey the law of gravity and remain floating, or suspended, in the water or other medium.

The processes of breaking, crushing, grinding and pulverising the ore with the object of separating the valuable from the gangue materials involve operations of a very ordinary character, that acquire interest by reason of the ingenuity shown in ensuring continuity of the process, and the precautions taken to secure economic treatment. But when the attempt is made to present a theory of crushing, a theory based on known physical laws, and tested by actual experiments designed to meet the needs or improve the efficiency of working conditions, the deficiencies of theory again become manifest. The author sets out the conclusions of two rival theorists, those of Rittinger and of Kick. Starting with certain assumptions, the conclusions arrived at seem clear, logical and consistent, yet they contradict each other. Rittinger asserts that to break a one-inch cube requires four times the energy necessary to break a half-inch cube, while Kick's rule or law demands twice as much energy to do the same work. There is much value in a compromise, and Herman would reconcile the two statements, by suggesting that Rittinger's argument gives the minimum power required for reducing material, and that of Kick, the maximum.

Passing over many practical details connected with sizing and classifying the broken ore, concentration and separation, and the forms of machinery necessary for the conduct of these operations, the author introduces the subject of flotation rather distrustfully, regarding it as an opponent to the continued development of the older methods of gravity concentration. This newer and much vaunted method does not prevent, or correct, metalliferous troubles, but it is a valuable process in supplementing and completing the work of gravity. As is well known, the process depends for success mainly on the buoyant effect of air bubbles to bring the metallic minerals to the surface and hold them there long enough to permit separation or removal. The process involves the addition of relatively minute quantities of oil and acid to the finely crushed ore (slightly roasted) when mixed with water, and agitating the mixture violently till a froth is formed, that preferentially collects the metallic sulphide minerals and carries them to the surface, where they can be skimmed off. Skilful manipulation on the part of the operator rather than the guidance of theory has made the process successful. The author attempts no explanation of the cause of the phenomenon, and does not quote any of the many solutions offered. We are still uncertain whether the explanation is to be sought in physical or chemical causes. Not the least perplexing part of the puzzle is offered by the selective affinity of oil and air for the sulphide minerals, and the total or partial lack of such affinity for the gangue materials.

The section on gold milling and plate amalgamation is less full and satisfactory than those on the dressing of baser metals. But, of course, much of the preparatory work in crushing and classifying resembles that already described. The account is interesting and might well be read by shareholders in South African mines. This remark might imply that the description is of rather a popular character, but the theory of cams, of the camshaft and of the weight of stamps is fully explained and instructive.

Measurement, Compression and Transmission of Natural Gas. By Lester Clyde Lichty. New York: John Wiley and Sons, Inc., London: Chapman and Hall, Limited. [Price 37s. 6d. net.]

Natural gas attracted attention and found a certain application, possibly by fire-worshippers in the first instance, long before the oil, with which the gas is generally associated, was utilised. The modern utilisation of natural gas goes back further than the present generation may assume. The village of Fredonia, in New York State, was illuminated and heated by natural gas in 1821; some gas wells have been flowing for a hundred years. By 1887 it was estimated that the gas utilised in the United States per year was equivalent to 10,000,000 tons of coal, and that very much more gas was lost. A few years previous gas flames had been roaring, day and night, from stand pipes all over the oil districts. The gas losses are still serious and the oil driller has reason to dread the "gusher" outbursts of oil and gas. It has been suggested that the words gas and gush (or gish) were derived from the same root. The word gas was coined by the Flemish alchymist van Helmont (who died 1644) in order to distinguish certain airs or vapours from ordinary air; whether or not he was guided in the selection of the name by the tendency of airs to gush out through any opening, is a controversial matter. The word quickly became as international as the air is—or was, until our days of flying.

Mr. Lichty, Associate Professor of Mechanical Engineering at the University of Oklahoma, does not give statistics on natural gas production, nor does he discuss its utilisation or the way the gas is caught at the oil well. There is a section on gasoline separation from natural gas, but the occurrence of helium in natural gas does not appear to be mentioned. Professor Lichty confines himself to his subject, "Measurement, Compression and Transmission of Natural Gas." His object was to compile a text-book on a comparatively new subject, which has only recently been added to the course of studies at engineering schools. The subjects call for a theoretical and a practical treatment. The student will require more of the former than of the latter; the engineer will chiefly look for technical detail. Both will find the volume of 523 pages useful.

The first two parts of the volume deal with the fundamental gas laws and the various methods and apparatus in use for measuring natural gas; the third part, on the compression of natural gas and the requisite machinery, and the fourth part on the transmission of the gas, pipe lines and their testing, are more strictly practical. But the technical character is well accentuated throughout. That Mr. Lichty quotes largely from papers on the subject and from the reports of the United States Bureau of Mines does not detract from the value of his compilation; the apparatus and machines and general information offered might be, however, less exclusively American. Pipe line crossings of rivers are illustrated, but submarine lines are not noticed. Some of the formulæ and the numerous tables, diagrams and graphs on gas density, expansion pressure, compressibility and gas flow would be applicable to gases generally; but the particulars given refer to natural gas.

The section on the decline of gas wells looks rather out of place in the first theoretical part on units and properties. The arrangement is justifiable on the grounds that special methods of measurements are adopted for anticipating, as far as possible, the depletion of a gas well before much has been spent on equipment, lines, meters, booster and compression stations, which might soon have to be removed or abandoned. The storage of natural gas in exhausted oil sands and the high-pressure regulation in transmission and distribution lines are peculiar to the gas. The rock pressures may be 600 lb. per square inch, while corporations mostly refuse to tolerate pipe lines carrying gas at more than 40 lb. per square inch through populated districts; high-pressure regulators are, therefore, placed near the well and near the city limits, and further regulators are provided in the houses. The high pressure in mains has also made the welding of pipe lines somewhat unpopular; the risks of fractures and repairs are great. Mr. Lichty does not say anything about accidents due to gas escapes. Considering the manifold risks and difficulties of the natural gas recovery and distribution, and the uncertainty of the supply, the development of the natural gas industry is highly creditable to American enterprise.

BOOKS RECEIVED.

Aufgaben aus dem Wasserbau Angewandte Hydraulik. By Dr. Ing. Otto Streck. Berlin: Julius Springer. [Price 2·75 dols.]

Electrical Machinery and Control Diagrams. By Terrell Craft. First edition. London: McGraw-Hill Publishing Company, Limited. [Price 15s. net.]

Elements of Cost Accounting. By Anthony B. Manning. First edition. London: McGraw-Hill Publishing Company, Limited. [Price 10s. net.]

United States Bureau of Standards. Circular No. 134, *United States Government Master Specification for Fire-Extinguishing Liquid (Carbon Tetrachloride Base).* [Price 5 cents.] Scientific Papers No. 486. *Some New Thermoelectrical and Actinoelectrical Properties of Molybdenite.* By W. W. Coblentz. [Price 10 cents.] Technologic Papers No. 257. *Development of a Method for Measurement of Internal Stress in Brass Tubing.* By R. J. Anderson and E. G. Fahlman. [Price 5 cents.] No. 258. *Strength of Steel Tubing under Combined Column and Transverse Loading, Including Tests of Columns and Beams.* By T. W. Greene. [Price 15 cents.] Washington: Government Printing Office.

Graphic Statistics in Management. By William Henry Smith. First edition. London: McGraw-Hill Publishing Company, Limited. [Price 20s. net.]

Seasonal Operation in the Construction Industries. The Facts and Remedies. Report and Recommendations of a Committee of the President's Conference on Unemployment. London: McGraw-Hill Publishing Company, Limited. [Price 10s. 6d. net.]

Die Elektrische Messtechnik I Die elektrischen Messmethoden im Allgemeinen. By J. Herrmann. Berlin and Leipzig: Walter de Gruyter and Co. [Price 1·25 gold marks.]

Elasticity and Strength of Materials Used in Engineering Construction. Section V. *Economic Theory of Steel Railroad Bridge Design.* By C. A. P. Turner. Minneapolis: C. A. P. Turner. [Price 5 dols.]

Aeronautical Research Committee. Reports and Memoranda No. 900. *Report of the Design Panel on the Scale Effect on Lift, Drag, and Centre of Pressure of Complete Aeroplanes.* [Price 2s. 6d. net.] No. 906. *The Measurement of Viscosity by Means of Capillary Tubes.* By Guy Barr, B.A., D.Sc. [Price 1s. net.] London: His Majesty's Stationery Office.

Air Ministry. Air Publication 878. *Handbook on the D.H.9A Aeroplane.* London: His Majesty's Stationery Office. [Price 2s. 6d. net.]

Pattern Making. By John McWilson. London: Constable and Co., Limited. [Price 3s. 6d. net.]

Moulding and Other Foundry Work. By William Bell. London: Constable and Co., Limited. [Price 3s. 6d. net.]

Pressure Gauges, Indicators, Thermometers, Pyrometers. By James Smith, B.Sc. London: Constable and Co., Limited. [Price 3s. 6d. net.]

Practical Microscopical Metallography. By Richard Henry Greaves, D.Sc., and Harold Wrighton, B.Met. London: Chapman and Hall, Limited. [Price 16s. net.]

A Hundred Years of Portland Cement, 1824–1924. By A. C. Davis, M.Inst.C.E.I., M.I.Mech.E., F.C.S. London: Concrete Publications, Limited. [Price 21s. net.]

United States Bureau of Standards. Scientific Papers. No. 488. *Thermal Expansion of Molybdenum.* By P. Herbert and W. B. Gero. [Price 10 cents.] No. 489. *Primary Radio Frequency Standardisation by the Use of the Cathode-Ray Oscillograph.* By G. Hagen and F. Kenyon. [Price 10 cents.] Washington: Government Printing Office.

Steam and Other Useful Tables for Engineers and Steam Users. By P. W. McGuire, M.I.Mar.E. London: E. and F. N. Spon, Limited. [Price 2s. net.]

Summary of Progress of the Geological Survey of Great Britain and the Museum of Practical Geology for the Year 1923. London: His Majesty's Stationery Office. [Price 4s. net.]

Special Reports on the Mineral Resources of Great Britain. Vol. XXVIII. *Refractory Materials; Fireclays, Analyses and Physical Tests.* By F. R. Ennos, B.A., B.Sc., and Alexander Scott, M.A., D.Sc. London: His Majesty's Stationery Office. [Price 3s. net.]

Memoirs of the Geological Survey. England and Wales. Explanation of Sheet 108. *The Geology of the Country around Flint, Hawarden and Caergwyle.* By C. B. Wedd, B.A., and others. London: His Majesty's Stationery Office. [Price 6s. 6d. net.]

COMMUTATOR MICA UNDERCUTTER.

COMMUTATOR MICA UNDERCUTTER.

A useful tool for the undercutting of the mica insulation of the commutators of direct-current machines, given the trade name "Paben," is shown in the accompanying illustration. This device is a simple hand tool and has been placed upon the market by Messrs. Pape and Bennison, of 23, Stanley-road, Barrow-in-Furness. The tool has a brass shank, to which are attached two wheels to act as guides and two hardened steel cutting blades. At one end of these blades, a groove is made so that two cutting edges are obtained, while there is a long pointed cutting edge at the other end. The blades are held on brass spindles and may be tightened up in suitable positions by means of cheese-headed screws, adjustment being possible for depth. Both the guide wheels and the blades, may be separated or brought together, to suit the pitch of the commutator segments. The tool may be used without the removal of the brushes or, indeed, of any part of the brush gear. In the illustration a heavy type is shown, such as is used for deep cutting on large machines, but a light tool, with either single or double blades, is also made and is provided with a single guide wheel or a movable guide blade. It may be noted that the cutting blades are easily renewed and resharpened and are inexpensive.

LABOUR NOTES.

In the National Minority Movement's statement of aims and objects, reproduced further on in these notes, there is, it will be observed, a declaration "against the present tendency towards social peace and class-collaboration and the delusion of a peaceful transition from Capitalism to Socialism." The idea of the average adherent to the National Minority Movement's policy is, of course, to overthrow Capitalism, and that being so, he has, in his own words "no use" for collaboration with employers. Happily, however, all workers are not believers in the policy of the National Minority Movement. A member of the Amalgamated Engineering Union, writing in the official organ of the Society, expresses sorrow that the *Monthly Journal* "has been utilised so much for propagating the class-war gospel. If we are going to suppress Capitalism," he declares, "we must have something better to put in its place. Meantime, we must make the best of it and try to fashion and direct it to give us the best results." In this engineer's opinion "the best and only way" in which to improve the lot of the workers is to strengthen the A.E.U. in membership and funds in order to enable it to meet its full obligation to its members. "That will be," he goes on to say, "the best lever we can put in the hands of the E.C. when trade revives to bargain with the employers for higher wages, and I am quite sure the employers will recognise the justice of our claims, the sooner we realise the folly of class-war propaganda and settle down in a spirit of co-operation to pull together for the common good. Belgium has set us an example industrially and was never busier to the mutual benefit of everybody. In the same way our industrial betterment lies, and not in any militant policy, which leaves the position of the worker worse every time."

According to Mr. Harry Pollitt, the Communist, the Federation of British Industries created in 1919 "a special secret organisation to link up and co-ordinate the policy of all employers in wages, hours and conditions. This secret organisation is called The National Confederation of Employers' Organisations." The National Confederation of Employers' Organisations is not a secret organisation. Its meetings are not, of course, open to the general public or the press, but neither are those of the General Council of the Trades Union Congress which represents organised workers pretty much as the Confederation represents organised employers.

A writer in *Man and Metal*, the journal of the Iron and Steel Trades Confederation, suggests that what the iron and steel industry needs is an increase of trade which will bring more of the existing plant into operation—not merely greater production with improved plant. It is a well-known fact, he goes on to say, that the larger furnaces and more efficient mills now in use have increased very considerably the output per man employed; but, in addition, we are constantly being told of cases where old plant is now giving better results than before the war. There is the widely circulated report of the two blast furnaces of the Seaton Carew Iron Company producing in one week 50 per cent. more than pre-war, and the less advertised fact that three steel melting shops under one control are producing under the eight-hour shift over 60 per cent. more than they were doing under the 12-hour shift system. In this case, the reasons for the increase appear to be, it is added, the shorter hours, more steel scrap, better gas, and generally more efficient organisation.

A study of industrial conditions in Russia issued by the International Labour Office at Geneva, contains some interesting information. It states that the average wage paid in State industry during the second half of 1923 was not more than 55 per cent. of the pre-war average, which itself was very low; yet these wages are still too heavy a burden on State industry, and the Government has taken steps to prevent further increases. This general tendency towards a fall in wages is attributed by the managers of nationalised industry to the many expenses which have to be borne in addition to wages properly so called. Real wages are far below the pre-war level. In spite of considerable increases in rates fixed by collective agreement and labour agreements, real wages are in practice always subject to reductions, and there is no improvement in the general situation of the working classes owing to the continual depreciation of the rouble and financial crises. After an examination of the position of the trade unions, the report says that the directing trade union bodies still regard themselves as Government bodies responsible for the actions of the Government, and in consequence defend and carry into effect the measures adopted by the economic authority. The vast non-political masses are thus losing confidence in the trade unions.

Russian Information and Review, which is published by the Information Bureau of the Trade Delegation in London of the U.S.S.R., contains an article on "Wages and the Productivity of Labour." In Russia, it states, the productivity of labour is still considerably below pre-war, but the efforts that have been made, and are being made, to improve it are yielding promising results. The tendency of the revolutionary period was for wages to increase at a greater rate than the productivity of labour. The 1917–1921 period was marked by an acute decline, both in productivity and in wages, but the decline in the first case was greater than in the second. In 1920, the monthly earnings of a worker were 40 per cent. of pre-war time, whereas productivity reached only 29 per cent. of the pre-war level. In recent years, the restoration of wages and productivity both show an uninterrupted advance. In the economic year 1921–22, the output of a worker, as compared with the previous year, increased by 78 per cent., while wages increased only by 35 per cent. From October, 1922, to March, 1924, the actual daily wage increased by 54·4 per cent., but the total productivity per worker per day rose only by 24·8 per cent. The corresponding increases for the period of April–May, 1924, were 56·6 per cent. and 29·1 per cent. In a period of 20 months, that is, the rise in the productivity of labour was only half that of the rise in wages. On the other hand, during recent months wages have remained practically stationary, whereas productivity has steadily increased.

The principal cause of the comparatively low productivity of labour is stated to have been the ruin wrought by the long years of Imperial and civil wars and intervention, followed by the famine and economic blockade. During these years it was not only impossible, it is pointed out, to replace worn-out machinery and other factory equipment, but, owing to the absence of spare parts and of skilled workers, who had gone to the various fronts, much of the machinery could not receive the necessary timely repairs, and thus became ruined. It is added that many factories are not yet working to their full capacity, owing partly to lack of capital and partly to the fact that in the short period that has so far elapsed since the Soviet Government has at last been free of civil war and foreign intervention, the centralisation and reorganisation of industry on a more economical basis has not yet been completed. On the other hand, the writer continues, the first care of the workers' and peasants' Republic has necessarily been to safeguard the interests of the workers to the utmost limit of the resources of the country. The working day has been cut down to eight hours. In some cases the worker is allowed time off for necessary meetings, &c., and in general he is treated as a thinking being and not as a mere "hand." As is usual in the U.S.S.R., all the defects in the organisation of industry are discussed frankly in Government departments, at workers' meetings, and in the press. The workers themselves are also taking the matter in hand, and a determined effort is being made to raise the productivity of labour in the near future.

The Ministry of Labour states that the number of unemployed persons recorded on the registers of Employment Exchanges in Great Britain on October 20, 1924, was 1,204,000—909,600 men, 35,500 boys, 226,800 women and 32,100 girls. On October 13, the number of unemployed persons was 1,210,201—915,274 men, 36,942 boys, 225,300 women and 32,685 girls, and on December 31, 1923, 1,285,623—946,521 men, 36,659 boys, 267,373 women and 35,070 girls.

On October 27, the Tramways Committee of Hull Corporation decided to accept the tender of Messrs. Bolckow, Vaughan and Company, Middlesbrough, for 1,500 tons of tram rails and 500 tons of sole plates, &c. The price was 12,291*l*. Originally, the City Council accepted a German tender which was 2,500*l*. lower, the Labour members voting with the majority. A lively controversy ensued, however, and in the end the Council cancelled its resolution, the Labour members acquiescing.

With the National Minority Movement's "programme of action" readers must now be fairly familiar, as the Red International Labour Union, which is directing the activities of the organisation, loses no opportunity of making it known. The "aims and objects" of the Movement are now publicly stated to be:—

1. To organise the working classes of Great Britain for the overthrow of Capitalism, the emancipation of the workers from oppressors and exploiters, and the establishment of the Socialist Commonwealth.

2. To carry on a wide agitation and propaganda for the principles of the revolutionary class struggle, and to work within the existing organisations of the workers for the purpose of fighting for the adoption of the programme of the National Minority Movement and against the present tendency towards social peace and class-collaboration and the delusion of a peaceful transition from Capitalism to Socialism.

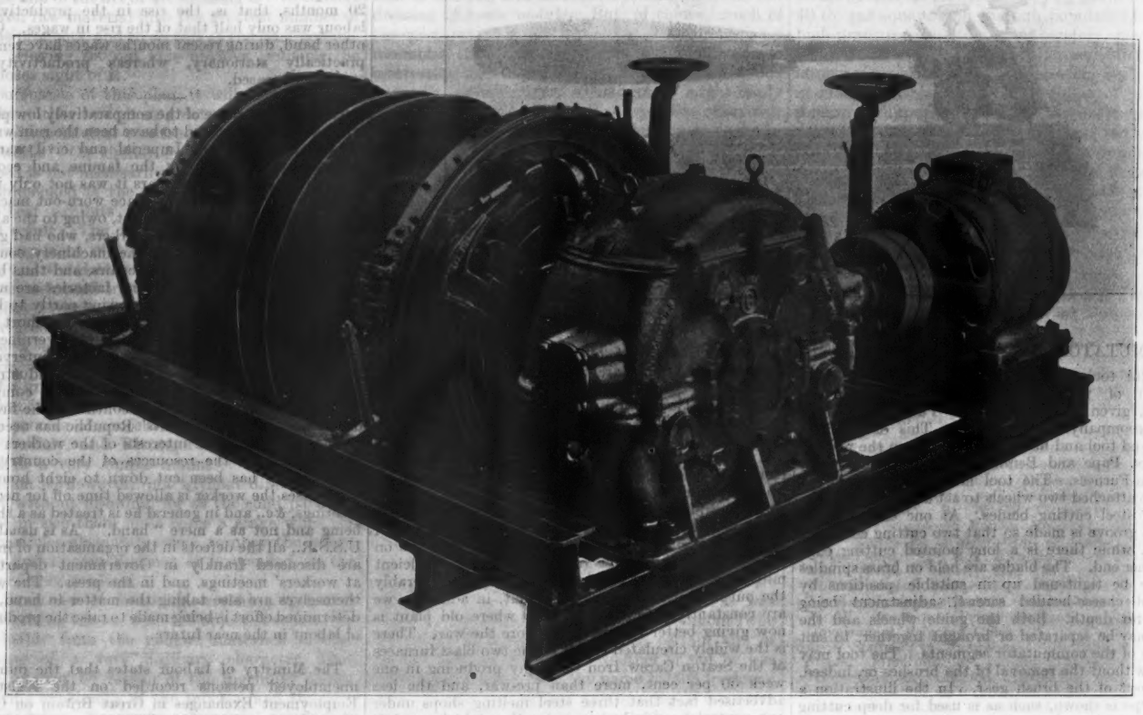
3. To unite the workers in their everyday struggles against Capitalism and at all times advance the watch-word of the united front of the workers against the exploiters.

4. To maintain the closest relations with the R.I.L.U. and to work for the unity of the International Trade Union Movement.

In the course of his address to the recent convention at Detroit of the International Association of Machinists, Mr. W. H. Johnson, the President, said that in an effort to work out a more satisfactory method of wage determination for members in Government service, District No. 44 had employed the Labour Bureau, Inc., to make a survey of wage theories and submit a report on the relation between wages and production. A Bill based upon their report had been

MAIN AND TAIL HAULAGE GEAR: BRITISH EMPIRE EXHIBITION.

CONSTRUCTED BY MESSRS. M. B. WILD AND CO., LIMITED, ENGINEERS, BIRMINGHAM.



prepared and introduced in Congress. It provided for the creation of a board upon which heads of departments and employées would have equal representation and laid it down that in its determination of wage rates the following factors should be taken into account:—

(*a*) The maintenance of a standard of living for the worker and his family which will insure health and decency.

(*b*) The relation between wages and the cost of living.

(*c*) The average change in per capita productivity of manufacturing industries in the United States over a period covering the preceding ten years.

(*d*) The progress made in per capita production in manufactories in the United States since 1900 which has not already been reflected in increased wages.

(*e*) The training and skill required.

(*f*) The degree of responsibility; and

(*g*) Inequalities of increases in wages or of treatment.

The Bill had been under discussion, Mr. Johnson said, but it had now been deemed advisable to wait for a more favourable opportunity to press the measure. At present, it stood as Labour's contribution towards the solution of the question and would, it was hoped, later receive the serious consideration of Congress.

The conventions of the International Association of Machinists are held every four years. The strike assessment or levy authorised at the 1920 meeting yielded, according to the General Secretary-Treasurer, Mr. E. C. Davison, 1,298,327 dols., but of that no less than 1,138,047 dols. went towards the payment of strike benefits drawn by members in 1919. Very little was, therefore, available for the period which it was designed to cover. Between September, 1920, and July, 1924, the total strike cost was 3,363,208 dols., although regular strike benefits were discontinued in July, 1922, and have not yet been resumed. The provision of strike benefits is, it may be added, giving the leaders of this organisation some concern. In his address at Detroit, Mr. Johnson said that the question ought to be faced fairly and squarely, and the rules amended so that the benefits payable were in accordance with the Association's ability to pay. The authorised benefits could not be paid, he claimed, to any large number of men unless the income was largely increased. The rules should also be strengthened, Mr. Johnson added, so as to provide that no financial assistance be given to any strike where the rules had not been complied with, and where sanction had not been secured prior to the men going on strike.

MAIN AND TAIL HAULAGE GEAR.

In our issue of August 22, we published on page 251, a description of a 25-h.p. main and tail electric haulage gear fitted with the Spence-Wild worm and spur reduction gearbox, mounted on a composite bed constructed of rolled joist and channel sections bolted together. The illustrations of the Spence-Wild worm and spur reduction gear shown in Figs. 115 and 116 are of the usual Spence-Wild type. We find, however, that the illustration reproduced in Fig. 117, on page 250, is that of an endless rope haulage gear, having the same type of reduction gear. In the illustration given on this page, we now reproduce the main and tail haulage gear actually installed in the mine at Wembley.

As we stated in our former issue, the drums have mild steel sides and cast-iron rolls, 2-ft. 6-in. diameter, and are 1 ft. 6 in. between the flanges, which are 9 in. deep. A brake ring is bolted to each side of the drum to receive the brake straps. The drum bosses are of cast iron of the through type, fitted with roller bearings to suit the drum shaft, which is 5 in. in diameter. The brake straps are of the all-round band reversible type, consisting of mild-steel straps lined with "Ferodo," operated by hand levers, conveniently arranged for the attendant. The clutches are of the external friction band reversible type, consisting of a mild steel strap, also lined with "Ferodo," carried on and driven by a semi-steel driver keyed to the drum shaft. The clutches are operated by means of hand wheels and screws through shafts and levers. The drum shaft is of mild steel, keywayed for the spur wheel, and arranged for the drums to run free on the roller bearings when not engaged with the clutches.

Death of Dr. Walter Boveri.—We regret to announce the death, on October 28, of Dr. Walter Boveri, one of the original founders of the firm of Messrs. Brown, Boveri and Co., of Baden, Switzerland.

Tender.—The municipal authorities at Antwerp are calling for tenders to be presented by November 21, for the construction of metal hangars. United Kingdom firms in a position to supply British materials can obtain further particulars regarding this call for tenders on application to the Department of Overseas Trade, 35, Old Queen-street, London, S.W. 1, quoting A.X. 1408.

THE LATE ENGINEER-COMMANDER CLARKE.

The death is announced of Engineer-Commander William Howard Clarke, D.S.O., who recently had charge of the Mechanical Repair Establishment of the Royal Navy at Devonport. He was the son of Mr. G. P. Clarke, of Devonport. After the usual course of naval training and promotion, he served during the European War in charge of the machinery of destroyers in the North Sea. He received the D.S.O. for a conspicuous act of coolness and gallantry, when chief engineer on the Melpomene, in an action which followed the start of a successful attempt to close the passage between the Thornton Ridge Shoal and the Belgian coast. Enemy destroyers attacked the British destroyers on the work, but they were driven off and, in their eagerness to get at the German vessels, the British destroyers went so far in towards Zeebrugge that they were all struck by shells from the shore batteries. The Melpomene was pierced in the engine room below the water line, and was taken in tow. On a further attack one of the two towing destroyers left the Melpomene and with the Murray engaged the enemy again, and drove them off. The Melpomene was safely brought in much to the credit of its engineer, who showed great resource in dealing with a difficult situation. In 1918 he was promoted Engineer-Commander and appointed Engineer Assistant to the Director of Warship Production at the Admiralty.

The Institution of Gas Engineers.—The Council of the Institution of Gas Engineers have decided to hold the annual meeting of the Institution next year in London, and it will take place in the Great Hall of the Institution of Civil Engineers, which has been lent for the purpose by the council of that body.

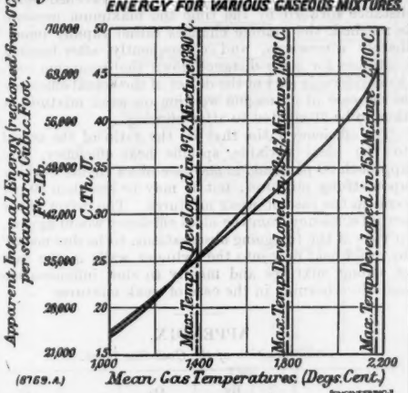
Fluxes and Slags.—On April 28 last, the Faraday Society and the Institute of Metals, in co-operation with the British Non-Ferrous Metals Research Association and the Institute of British Foundrymen, held a general discussion on "Fluxes and Slags in Metal-Melting and Working." The meeting, which took place in the Institution of Mechanical Engineers, was noticed on pages 582 and 583 of our issue of that week, May 2. The full report of the discussion has now been issued in pamphlet form, and can be obtained from the Faraday Society, 90, Great Russell-street, W.C. (price 7*s.* 6*d.* net). The papers read were interesting, and the discussions would have been even more so if some of the members had spoken out more freely.

THE MISSING PRESSURE IN GAS ENGINES.*

By PROFESSOR W. T. DAVID, M.A., D.Sc.

IT was noticed by the earliest experimenters interested in the internal-combustion engine that the pressures developed on explosion of the charge were less than half those which were calculated from the known calorific value of the fuel on the assumption that the working fluid (which contains normally more than 80 per cent. of nitrogen) behaves like ideal air. A study of the experimental work on the subject seemed to indicate that the solution of the problem of the missing pressure was practically impossible by means of experiments of a more or less direct nature, and the author adopted an indirect method of experimenting which he believes has yielded reliable information. His method was that of determining the internal energy of a weak mixture of coal gas and air exploded in a closed vessel in the neighbourhood of its maximum temperature, and comparing it with that of a strong mixture when it had cooled to the same temperature as the weak mixture had at this time. For this purpose it was necessary to determine the heat loss during the explosion and subsequent cooling of the gaseous mixtures, and to record the pressures developed simultaneously in order that the temperature of the mixtures might be inferred therefrom. Three sets of records are given in Tables I, II and III, which show the mean gas temperature and the heat loss to the walls of the vessel† during the explosion and subsequent cooling of a strong mixture (15 per cent. coal gas and air), a medium mixture (12·4 per cent. coal gas and air) and a weak mixture (9·7 per cent. coal gas and air). The experimental methods adopted need not here be described. It suffices to say that the gas-pressure curves and the heat-loss curves were recorded simultaneously by optical means on the same photographic film. The heat of combustion of the gas present in the vessel before explosion, less the heat loss over the entire surface of the vessel during the time taken by the gaseous mixture to explode and afterwards cool down to any given temperature, is a measure of the energy remaining in the mixture at that temperature over and above that which it possesses at atmospheric temperature.

Fig. 5. CURVES OF APPARENT INTERNAL ENERGY FOR VARIOUS GASEOUS MIXTURES.



As an example, the energy remaining in the 15 per cent. mixture after it has cooled down to a temperature of 2,000 deg. abs. may be given. The heat of combustion of the gas in the vessel before explosion was 36 C.Th.U. During explosion and subsequent cooling down to 2,000 deg. C. abs., the heat loss amounted to 12·9 C.Th.U. The energy remaining in the gaseous mixture after cooling to this temperature was, therefore, $36 - 12{\cdot}9 = 23{\cdot}1$ C.Th.U. The figures in column 5 of Tables I, II and III have been calculated in this way. In column 6 of the tables the energy values are given per standard cubic foot of the exploded mixture, and are measured from the datum level of 0 deg. C., while in the last column the energy values (still reckoned from the datum level of 0 deg. C.) are given in foot-pounds per standard cubic foot.

Conclusions drawn from Closed Vessel Experiments in regard to the causes responsible for the Missing Pressure.—The data in these tables (columns 3 and 7) have been plotted in Fig. 5. The curves show the energy (reckoned from 0 deg. C.) remaining in the gaseous mixture per standard cubic foot at various temperatures ranging from the maximum developed down to 1,000 deg. C. The most noticeable feature of the curves is that the energy remaining in the weaker mixtures in the neighbourhood of their maximum temperatures, and in the initial stages of cooling, is greater than that remaining in the stronger mixtures when they have been cooled to the same temperatures as the weaker mixtures possess in this epoch—even though the stronger mixtures contain a larger proportion of CO_2 and steam than the weaker mixtures. These results must be taken as indicating that the energy in the gaseous mixtures at the moment of maximum pressure and in the initial stages of cooling is partly thermal and partly chemical. In other words, that combustion is not complete at the moment of maximum temperature and indeed is only completed after cooling has been proceeding for some time.

Assuming then that the energy in the gaseous mixtures at the moment of their maximum temperatures, and in the initial stages of cooling, consists partly (and mainly) of thermal energy and partly of available chemical energy, an estimate of the amount of chemical energy in the gaseous mixtures may be made from the curves in Fig. 5. Such an estimate is obtained by subtracting from the energy values of the weaker mixtures at any given temperature, the energy values of the stronger mixtures when they have cooled to the same temperature (by which time the chemical energy has all been converted into thermal energy), after making a small allowance for the difference in composition of the mixtures. In order to make this clear, the amount of the energy in chemical form at the moment of maximum pressure and temperature in the 9·7 per cent. mixture will be found. From the curve for this mixture in Fig. 5, the energy in it at the moment of maximum temperature (1,390 deg. C.) is 26·6 C.Th.U. per standard cubic foot. The energy in the strong (15 per cent.) mixture after cooling to this temperature is 25 C.Th.U., and by this time the energy is entirely thermal. Had the composition of the strong mixture after combustion been the same as that of the 9·7 per cent. mixture after combustion, it is estimated that its internal (thermal) energy at this temperature would have been 1·4 C.Th.U. less, that is, it would have been 23·6 C.Th.U. The energy in chemical form in the 9·7 per cent. mixture at its maximum temperature is thus $26{\cdot}6 - 23{\cdot}6 = 3{\cdot}0$ C.Th.U. per standard cubic foot.

Estimates obtained in this way of the available chemical energy at the moment of maximum pressure in the 12·4 per cent. and the 9·7 per cent. mixtures are shown in Table IV.

It will be seen that of the energy in the gaseous mixtures at the moment of their maximum temperatures, about 88 per cent., on the average, is in the thermal form and about 12 per cent. is unconverted chemical energy.

In Table V heat balances are given for these mixtures showing the distribution of the heat of combustion of the coal-gas per standard cubic foot of the burnt mixture at the moment of maximum temperature.

TABLE I.

Internal energy of 15 per cent. mixture of coal-gas and air after explosion, that is, a mixture of 48 C.Th.U. per standard cubic foot. Heat of combustion of coal-gas in vessel 36·0 C.Th.U.

Composition of mixture after combustion: N_2 and O_2 71·5 per cent.; CO_2 8·5 ,, ; H_2O 20·0 ,,

Time after Ignition.	Mean Gas Temperature.	Mean Gas Temperature.	Total Heat loss over whole Surface of Vessel.	Internal energy of Gaseous Mixture Reckoned from Atmospheric Temperature.	Internal energy of Gaseous Mixture per Standard Cubic Foot of Burnt Mixture Reckoned from 0° C.	Internal Energy of Gaseous Mixture per Standard Cubic Foot of Burnt Mixture Reckoned from 0° C.
Secs.	° C. abs.	°C.	C.Th.U.	C.Th.U.	C.Th.U.	Ft.-lb.
0	—	15	0	(36·00)	(50·25)	(70,300)
0·05	2,440 (Max. temp.)	2,170	3·18	32·82	45·75	64,000
0·06	2,400	2,130	5·02	30·98	43·25	60,500
0·1	2,200	1,930	9·43	26·57	37·3	52,200
0·15	2,000	1,730	12·90	23·10	32·3	45,200
0·22	1,800	1,530	16·02	19·98	28·05	39,200
0·3	1,600	1,330	18·90	17·10	23·95	33,500
0·42	1,400	1,130	21·92	14·08	19·9	27,900

TABLE II.

Internal energy of 12·4 per cent. mixture of coal-gas and air after explosion, that is, a mixture of 39·6 C.Th.U. per standard cubic foot. Heat of combustion of coal-gas in vessel 29·75 C.Th.U.

Composition of mixture after combustion: N_2 and O_2 76·6 per cent.; CO_2 7·0 ,, ; H_2O 16·4 ,,

Time after Ignition.	Mean Gas Temperature.	Mean Gas Temperature.	Total Heat Loss over whole Surface of Vessel.	Internal Energy of Gaseous Mixture Reckoned from Atmospheric Temperature.	Internal Energy of Gaseous Mixture per Standard Cubic Foot of Burnt Mixture Reckoned from 0° C.	Internal Energy of Gaseous Mixture per Standard Cubic Foot of Burnt Mixture Reckoned from 0° C.
Secs.	°C. abs.	°C.	C.Th.U.	C.Th.U.	C.Th.U.	Ft.-lb.
0	—	15	0	(29·75)	(41·25)	(57,700)
0·08	2,050 (Max. temp.)	1,780	2·99	26·76	37·5	52,500
0·11	2,000	1,730	4·63	25·12	34·95	48,900
0·2	1,800	1,530	8·98	20·77	29·0	40,600
0·3	1,600	1,330	12·52	17·23	24·1	33,700
0·45	1,400	1,130	15·73	14·02	19·9	27,900

TABLE III.

Internal energy of 9·7 per cent. mixture of coal-gas and air after explosion, that is, a mixture of 31 C.Th.U. per standard cubic foot. Heat of combustion of coal-gas in vessel 23·36 C.Th.U.

Composition of mixture after combustion: N_2 and O_2 81·6 per cent.; CO_2 5·5 ,, ; H_2O 12·9 ,,

Time after Ignition.	Mean Gas Temperature.	Mean Gas Temperature.	Total Heat Loss over whole Surface of Vessel.	Internal Energy of Gaseous Mixture Reckoned from Atmospheric Temperature.	Internal Energy of Gaseous Mixture per Standard Cubic Foot of burnt Mixture Reckoned from 0° C.	Internal Energy of Gaseous Mixture per Standard Cubic Foot of Burnt Mixture Reckoned from 0° C.
Secs.	°C abs.	°C.	C.Th.U.	C.Th.U.	C.Th.U.	Ft.-lb.
0	—	15	0	(23·26)	(32·15)	45,000
0·18	1,660 (Max. temp.)	1,390	4·15	19·21	26·6	37,100
0·24	1,600	1,330	5·90	17·46	24·25	33,900
0·31	1,500	1,230	7·93	15·43	21·45	30,000
0·4	1,400	1,130	9·48	13·88	19·35	27,100

TABLE IV.

Proportion of the energy (reckoned from 0 deg. C.) remaining in the gaseous mixture at the moment of maximum temperature in the form of internal energy and available chemical energy.

Mixture.	Energy Remaining in Gaseous Mixture per Standard Cubic Foot of Burnt Mixture.	Internal thermal Energy per Standard Cubic Foot.	Available Chemical Energy per Standard Cubic Foot.
Per cent.	C.Th.U.	C.Th.U.	C.Th.U.
12·4	37·5	32·7	4·8
	100·0	87·0 per cent.	13·0 per cent.
9·7	26·6	23·6	3·0
	100·0	89·0 per cent.	11·0 per cent.

TABLE V.

Distribution of the heat of combustion of the coal-gas per standard cubic foot at the moment of maximum temperature.

Mixture.	Heat of Combustion.	Internal Thermal Energy.	Available Chemical Energy.	Heat Loss to Walls of Explosion Vessel.
Per cent.	C.Th.U.	C.Th.U.	C.Th.U.	C.Th.U.
12·4	41·25	32·7	4·8	3·75
	100·0	79·0 per cent.	11·5 per cent.	9·5 per cent.
9·7	32·15	23·6	3·0	5·55
	100·0	73·0 per cent.	9·5 per cent.	17·5 per cent.

It will be seen from the table that about 10 or 11 per cent. of the coal-gas originally in the vessel is unburnt in each mixture at the moment of maximum pressure, and it seems probable that there is approximately the same proportion of unburnt gas in the 15 per cent. mixture at this moment. The maximum pressure is therefore reached under the ideal conditions obtainable in closed-vessel experiments, when about 90 per cent. of the coal-gas has been completely burnt. The heat loss to the walls of the vessel up to this moment ranges from 9 per cent. in the 12·4 per cent. mixture to nearly 18 per cent. in the 9·7 per cent. mixture.* The proportion of the heat of combustion in the form of thermal energy at the moment of maximum pressure varies from 79 per cent. in the stronger mixture to 73 per cent. in the weaker mixture. Had the gaseous mixture after combustion a constant specific heat equal to that of air at atmospheric temperature and the pressures developed in the mixtures remained the same as those actually observed, the proportion of the heat of combustion which would have been

* Paper, abridged, read before the Institution of Mechanical Engineers on Friday, October 24, 1924. The Author's numbering of the figures has been retained.

† The explosion vessel consisted of a cast iron cylinder on to which were bolted two end covers. Its diameter was 12 in. and its length also 12 in.

* The greater relative heat loss in the 9·7 per cent. mixture is due to the fact that it has a much longer explosion period.

accounted for as thermal energy would only have been 57 per cent. in the case of each mixture. The differences between this figure and those shown in the second column of the table is a measure of the average increase of the specific heat over the temperature ranges corresponding to the two mixtures.

It will be clear from these results that the missing pressure, or so-called suppression of heat, in gaseous explosions is due to the three causes of incomplete combustion, increasing specific heat, and heat loss to the walls of the vessel during the explosion period. The extent to which incomplete combustion contributes to the limiting of the pressures is not very different in the mixtures experimented upon, but the extent to which the other two causes contribute to this varies considerably from mixture to mixture.

Estimated Ideal Pressures in the Closed Vessel.—The significance of these results will perhaps be the more readily appreciated if the pressures which would have been developed, had it been possible to prevent heat loss to the walls of the vessel and also were it possible to speed up combustion to such an extent that the coal-gas was completely burnt during the explosion period, are determined. These may be calculated for the 12·4 per cent. and the 9·7 per cent. mixtures from the data furnished by the experiments just described and are given in Table VI. The pressure rises, calculated on the assumption that the gaseous mixtures possess the properties of ideal air, are also given in this table.

Table VI.

Mixture Strength.	Actual Maximum Rise of Pressure.	Calculated Rise of Pressure if Heat Loss during the Explosion Period were Checked.	Calculated Rise of Pressure if Heat Loss were Checked and Combustion Completed During the Explosion Period.	Calculated Rise of Pressure if Gaseous mixture had constant Specific Heat Equal to that of Air at Ordinary Temperatures. (Heat Loss Checked and Combustion Completed.)
Per cent.	Lb. per sq. in.	Lb. per sq. in.	Lb. per sq. in.	Lb. per sq. in.
12·4	87	98	108	155
9·7	73	88	96	125

It will be seen from the table that if the heat loss during the explosion period could be prevented, the rise of pressure would have been increased by about 12 per cent. in the 12·4 per cent. mixture and by about 19 per cent. in the 9·7 per cent. mixture. Had it been possible to prevent heat loss and to speed up the combustion so that it is completed during the explosion period, the increases in the rise of pressure would have been about 24 per cent. and 31 per cent., respectively, greater than the pressure rises calculated on the basis of no heat loss and complete combustion within the explosion period.

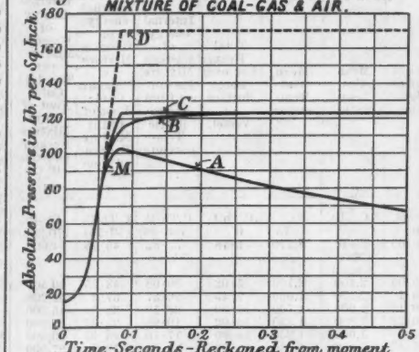
Actual and calculated pressure curves to a time-base for the 12·4 per cent. and the 9·7 per cent. mixtures are shown in Figs. 6 and 7. The A curves show the pressures actually developed in the explosion vessel; the B curves the pressures which would have been developed had it been possible to prevent heat loss, and the C curves the pressures which would have been developed had it been possible to prevent heat loss and to complete the combustion during the explosion period. The D curves (dotted) show the theoretical air pressures under conditions of complete combustion within the explosion period and no heat loss. It will be noted that the B curves approach the C curves as combustion becomes complete, as, of course, would be expected. These curves indicate that combustion is practically complete about a quarter of a second after the moment of maximum pressure, but the rate of burning during this interval is not constant; it becomes less and less as cooling proceeds. About half of the 10 per cent. of the coal-gas remaining unburnt at the moment of maximum pressure appears to be burnt within one-twentieth of a second.

Application of Results of Closed-Vessel Experiments to the Gas Engine.

The "Combustion Factor."—The author has found it convenient to call the proportion of the heat of combustion of the fuel which has been converted into thermal energy by the time the maximum pressure is reached, the "combustion factor." It is not possible to say, in the present state of knowledge, to what extent this factor varies with volume, density and temperature before firing, but various considerations lead to the conclusion that within the limits of density, volume, and temperature usual in gas-engine practice, any such variation will not be very large. Assuming this to be so, it is considered that the combustion factor of 90 per cent. obtained in the closed-vessel experiments is probably the maximum attainable in gas engines fitted with ordinary ignition systems.

Assuming the internal energy values deduced from Fig. 5 after chemical and thermal equilibrium has been established, the author, from an examination of typical indicator diagrams taken by Sir Dugald Clerk and the late Professor Bertram Hopkinson, has found that in none of the cases examined does the thermal energy added to the gaseous mixture by the time the peak of the indicator diagram is reached, account for more than 70 per cent. of the heat of combustion of the fuel charge, even after making an allowance of 5 per cent. for heat loss to the cylinder walls during explosion.* In other words, the combustion factor (referred to the peak of the indicator diagrams) is only of the order of 70 per cent.

Fig. 6. PRESSURE CURVES FOR 12·4 PER CENT MIXTURE OF COAL-GAS & AIR.

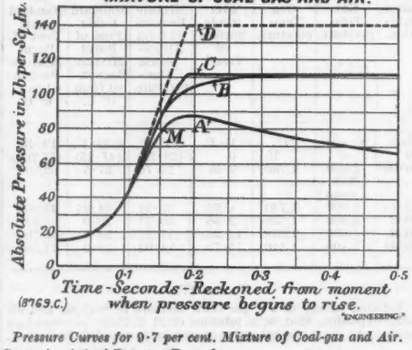


(8163.B.)

Pressure Curves for 12·4 per cent. Mixture of Coal-gas and Air.

Curve A.—Actual Pressure Record.
Curve B.—Pressure assuming all Heat Loss prevented.
Curve C—Pressure assuming all Heat Loss prevented and Combustion completed by Moment of Maximum Pressure.
Curve D—Pressure supposing the gaseous mixture to have a Constant Specific Heat equal to that of Air; Heat Loss prevented and Combustion complete by Moment of Maximum Pressure.
Point M—Point at which Flame completely fills Explosion Vessel.

Fig. 7. PRESSURE CURVES FOR 9·7 PER CENT MIXTURE OF COAL-GAS AND AIR.



(8163.C.)

Pressure Curves for 9·7 per cent. Mixture of Coal-gas and Air.

Curve A—Actual Pressure Record.
Curve B—Pressure assuming all Heat Loss prevented.
Curve C—Pressure assuming all Heat Loss prevented and Combustion completed by Moment of Maximum Pressure.
Curve D—Pressure supposing the gaseous mixture to have a Constant Specific Heat equal to that of Air; Heat Loss prevented and Combustion complete by Moment of Maximum Pressure.
Point M—Point at which Flame completely fills Explosion Vessel.

With advanced ignition, higher combustion factors may doubtless be reached, but in view of the foregoing results it seems improbable that combustion factors greater than about 70 per cent. are realised in gas engines with normal ignition. There seems little doubt, therefore, that incomplete combustion ranks equally with increasing specific heat as a primary cause limiting the maximum pressures developed in gas engines.

Reason for the Low Combustion Factors realised in Gas Engines and the effect of After-Burning upon Efficiency.—In order to understand the reason for the low combustion factors obtained in gas engines as compared with those realised in closed vessels, it is necessary to consider what happens during the explosion of a gaseous mixture, and in particular to distinguish between inflammation and complete combustion.

Consider first the process of explosion in a closed vessel. From the pressure records (Figs. 6 and 7) it will be seen that the pressure rises slowly at first and then with increasing speed, until a maximum rate of increase is attained which remains constant until the point marked M is reached. Afterwards the rate of increase becomes less and less until the maximum pressure is developed, and then the pressure begins to fall.

It is now known that at, or near, the point M, inflammation has spread completely through the gaseous mixture. At this moment about three-quarters of the gas appears to be burnt; the burning of the remaining quarter, which may be referred to as "after-burning,"* takes rather more than a quarter of a second. At first it is sufficiently rapid to more than balance the cooling, and the pressure continues to rise, but later it becomes smaller and smaller and the cooling causes the pressures to decrease.

Various considerations lead the author to believe that in gas engines with normal ignition the maximum pressure (as indicated by the peak of the indicator diagram) occurs generally more or less in the neighbourhood of the moment of complete inflammation, which, as has been stated, marks the end of the period of the maximum rate of rise of pressure in the closed vessel. After-burning then continues during the expansion stroke. Generally the bulk of the after-burning in strong mixtures developing vertical explosion lines on the indicator diagram, is probably effected in the early stages of the stroke, owing to the fact that the volume changes comparatively slowly in this epoch. Consequently, the effect of after-burning upon thermal efficiency is not great, and obviously it is desirable, from a mechanical point of view, in that it tends to reduce the ratio of the maximum pressure to the mean effective pressure. The matter is different, however, in the case of weak mixtures giving sloping explosion lines. As the piston has travelled some distance forward by the time the maximum pressure is reached, the volume changes rather rapidly immediately afterwards, and consequently after-burning continues for some distance down the expansion line. A considerable part of the defect of the actual efficiency in the case of an engine working on weak mixtures is thus to be attributed to after-burning.

The efficiency ratio, that is, the ratio of the actual to the ideal variable specific heat efficiency, may approach 90 per cent. in the case of an engine working upon strong mixtures, but it may be less than 80 per cent. in the case of weak mixtures. The defect of the actual efficiency from the ideal efficiency would appear, in view of the foregoing observations, to be due mainly to rapid heat flow into the cylinder walls in the case of strong mixtures and mainly to slow inflammation and after-burning in the case of weak mixtures.

APPENDIX.

Composition of the Coal-Gas Used.

—	By Volume.	O_2 Required.	Steam.	CO_2.
	Per cent.			
H_2	47·2	23·6	47·2	—
CH_4	35·2	70·4	70·4	35·2
Heavy Hydrocarbons	4·8	22·6	16·0	14·4
CO	7·15	3·6	—	7·15
N_2	5·4	—	—	—
Other gases	0·25	—	—	—
—	100·0	120·2	133·6	56·75

The Dismantling of the Cyfarthfa Ironworks.—Following on their recent purchase of Bessemer's Bolton works, Messrs. Thos. W. Ward, Limited, of Briton Ferry and Sheffield, inform us that they have now acquired the blast furnaces, blowing engines and stoves at the Cyfarthfa Ironworks, Merthyr Tydfil. In this connection it may be of interestto mention that the Cyfarthfa Works were founded in 1765, and at the end of the eighteenth century they were probably the largest ironworks in the world, employing over 1,000 men at that time, and exporting their products to all parts of the globe. In the first half of the nineteenth century, the works found employment for about 5,000 men and were largely engaged in the manufacture of the iron rails required for the development of railways in this country and abroad. They were converted for the production of Bessemer steel when this process was introduced, and continued for many years to play an important part in the British steel industry, remaining in private ownership until 1890. In that year, the concern was formed into a limited liability company which was acquired about twelve years later by Messrs. Guest, Keen and Nettlefolds, Limited. Activities were continued during the last decade with varying degrees of success, the works being busily engaged on the production of munitions during the late war. Soon after hostilities however, they were closed down, and the end of another interesting and important chapter in the British iron and steel industry will be reached when the plant above referred to is finally dismantled by Messrs. Ward.

* See Engineering, March 10, 1922, page 281.

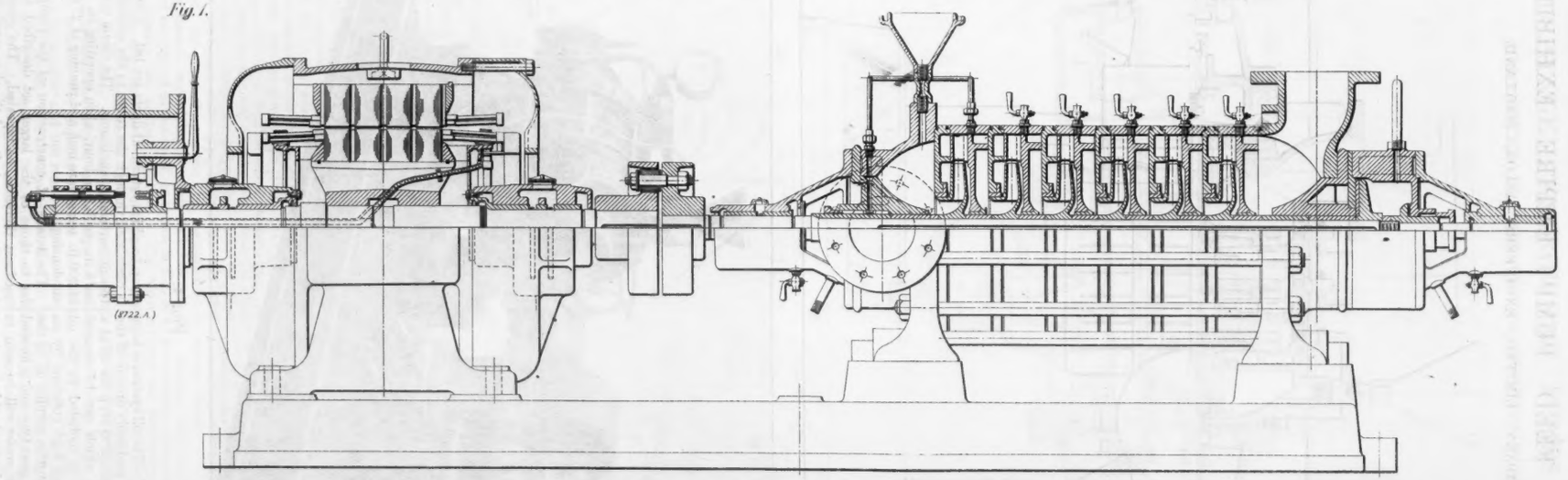
* It should be noted that the expression "after-burning" is here used to refer to the burning which takes place after the moment of complete inflammation. Hitherto it has been employed in referring to the burning which takes place after the maximum pressure has been reached.

SIX-STAGE TURBINE PUMP FOR 700-FT. HEAD AT THE BRITISH EMPIRE EXHIBITION.

SIX-STAGE TURBINE PUMP FOR 700-FT. HEAD AT THE BRITISH EMPIRE EXHIBITION.

CONSTRUCTED BY THE BRITISH ELECTRIC PLANT COMPANY, LIMITED, ENGINEERS, ALLOA, SCOTLAND.

Fig. 1.



CENTRIFUGAL PUMPS AT THE BRITISH EMPIRE EXHIBITION.

THE British Electric Plant Company, Limited, of Alloa, Scotland, who have been manufacturing centrifugal and high lift turbine pumps since 1907, have had a representative display of such machines at the British Empire Exhibition at Wembley. The largest of these is a pump designed to deliver 1,000 gallons per minute against a 1,700-ft. head, running at 1,450 r.p.m. Another set is illustrated in Figs. 1 and 2 herewith. This set, direct driven by electric motor, is designed for a 700-ft. head and an output of 650 gallons per minute. The sectional drawing shows various interesting features of design. The motor is of 200 h.p. capacity, and the set runs at 1,460 r.p.m. The pump has six impellers, which discharge the water through passages and ports leading from one chamber to the next. The suction and delivery branches are carried by end covers. These and the intervening chambers are all registered together, long bolts running through to the end covers. The latter are provided with feet. The pipe exits may be at any right angle to the horizontal, but the firm's standard design provides for the suction branch to be at the right side looking from the driving end, the delivery branch being at the top. Other positions can, however, be arranged.

Each pump stage consists of a chamber and closing plate, with impeller and guide passages. The impellers are provided with one neck ring only in the eye. This has extra wide surfaces with the object of keeping the efficiency high and giving the pump a long life. The impellers are machine finished and polished. The water passages are cleaned up. The use of a single necking reduces the leakage of water at the eye by one-half that usual with double neck rings and balancing holes through the web. The frictional losses are likewise reduced. The guide ports are designed to secure the conversion to pressure of the maximum possible amount of velocity energy of the water. They are machined and polished all over. They are spigoted into the chambers and firmly clamped, but are easily removed should attention or renewal be necessary. The guide ports and impellers are usually of gun-metal or phosphor-bronze. Both parts, however, can be made of cast iron for use with water of good quality, or for short period service. The shaft is usually of mild steel, nickel steel or of other metals as conditions may demand. Sometimes the shaft is protected as shown in Fig. 1 by non-ferrous metal sleeves between the stages. Such sleeves can be easily renewed and replaced in the event of wear taking place.

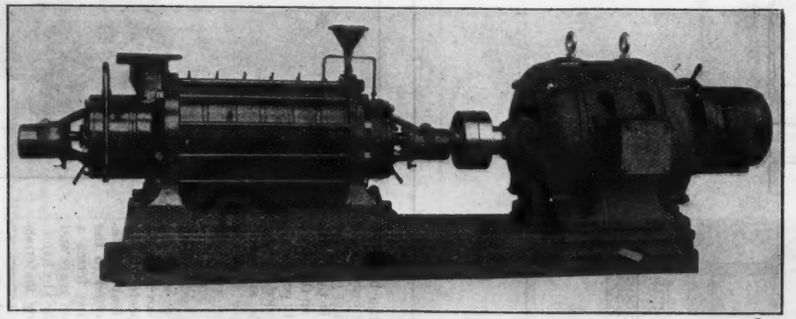


FIG. 2.

The stuffing boxes and glands are not subjected to high pressures. The suction gland is sealed from the first chamber, which has only a few feet head. At the delivery end the gland is placed beyond the balance disc, and there is no pressure across this gland. This arrangement greatly reduces the amount of leakage and does not necessitate tight glands, a small quantity of leakage sufficing to keep the stuffing box cool. The shaft bearings are separate from the pump casing at both ends; they are ring lubricated.

The hydraulic balance is obtained by means of a very simple form of balance disc. This, as shown in our drawing, is fitted at the delivery end, water, at full pressure from the delivery chamber, being allowed to pass along the back bearing and flow out radially between the balance disc and a renewable rubbing plate. From the periphery of these the water is collected in a balance chamber fitted with an overflow pipe. The balance chamber is at practically atmospheric pressure. The end thrust of the pump forces the balance disc up against the plate. The two are kept apart and lubricated by the thin film of high pressure water. With the balance disc correctly proportioned just the right amount of water will flow between it and the plate to balance the end thrust, and the water escaping will not be more than from 2 to 3 gallons per minute. If the end thrust should increase slightly, the disc and plate will be brought nearer together and the water passing will be reduced in quantity. The pressure at the inner circumference then rises, and the mean pressure on the disc increases until it suffices to balance the end thrust again. Should the end thrust of the pump diminish, the water leakage past the disc increases until the pressure inside has been reduced and conditions of equilibrium are re-established.

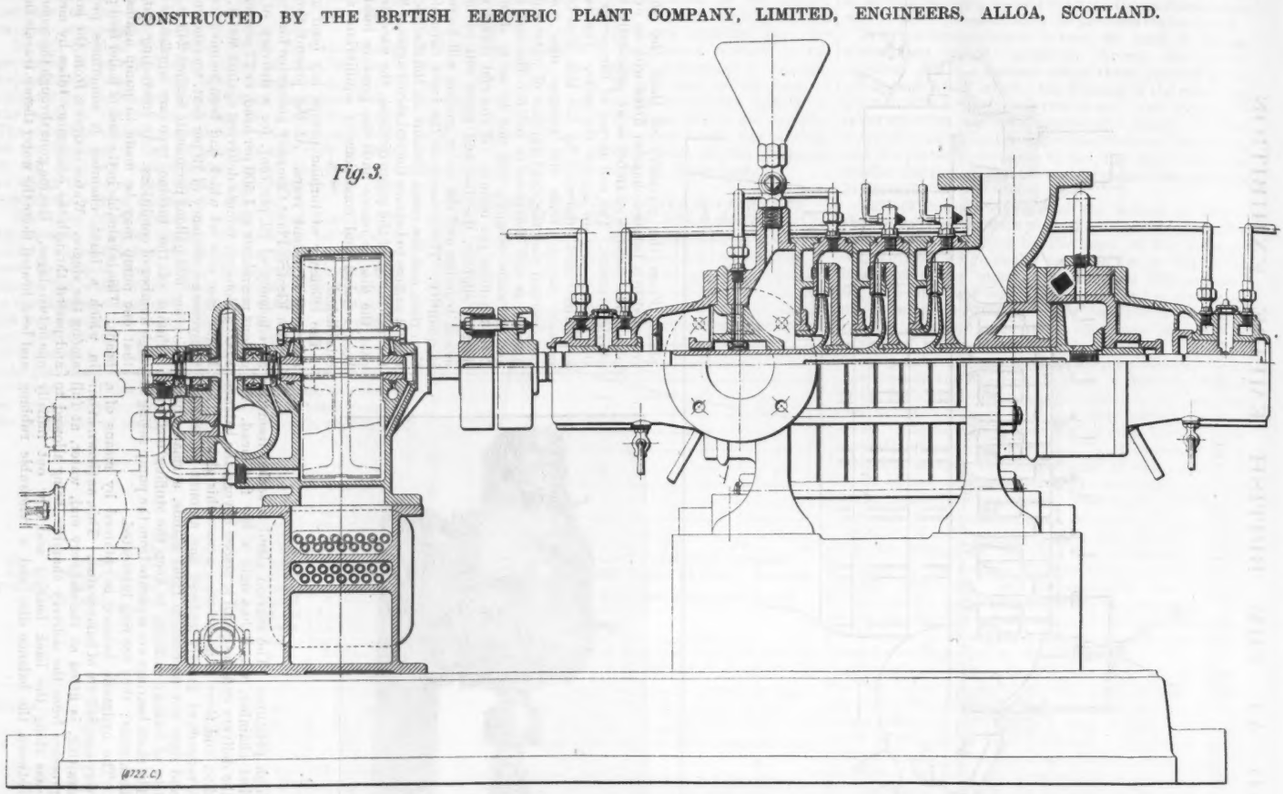
The efficiency of turbine pumps has been greatly improved of recent years. At the present time the British Electric Plant Company guarantee for example an efficiency of 79 per cent. for a delivery of 1,000 gallons per minute at 1,500 per head, or 77 per cent. for 1,000 gallons per minute delivered against 800 ft. head. In the case of a set which had been running for over two years an efficiency of 79 per cent. was shown when delivering 600 gallons per minute against 243 ft. head.

Pumps of the turbine type are applicable to a large number of conditions. An interesting feature is that one pump may be made to pump against two heads. This is valuable in the case of boiler feed pumps in which a blank chamber is sometimes provided among the stages. Water is drawn from the hot well and passed through the economiser tubes by means of one or two stages. Having gone through the economiser and been heated there the water thence travels through

TURBINE-DRIVEN CENTRIFUGAL BOILER FEED PUMP; EMPIRE EXHIBITION.

CONSTRUCTED BY THE BRITISH ELECTRIC PLANT COMPANY, LIMITED, ENGINEERS, ALLOA, SCOTLAND.

Fig. 3.



the remaining stages and is forced into the boiler at high pressure. The economisers are thus only under low pressure, and are not subject to full boiler pressure.

Among the firm's exhibit at Wembley is the boiler feed pumping set illustrated in Figs. 3 and 4 on this page. This set is designed to feed a boiler at 200 lb. per square inch pressure at the rate of 200 gallons per minute, when running at 3,000 r.p.m. These sets are either steam or electrically driven. The example shown is geared to a 50-h.p. steam turbine running at 30,000 r.p.m., with 10 to 1 single reduction. To ensure permanent alignment, unit construction is adopted for the turbine and gears. The main turbine and gear casings form part of a single casting, the covers being separate, so that either part can be inspected. The rotor can be removed without breaking steam joints. The governor case is of one piece and bolted to the side of the main casing. The main casing forms a rigid frame for the impulse wheel, reduction gears and main bearing. All machine faces are finished by hand-scraping to a face plate, and no soft jointing materials are used under the covers. The bearing recesses are cut by special tools, provision being made on each side of the impulse wheel for oil scrapers and carbon bushes. The impulse wheel, pinion and shaft are forged from a solid ingot of heat treated nickel-chrome steel. Machine-cut double-helical teeth are used for the gears, the oil throwers and thrust collars being solid with the shaft. The gear wheel is of heat-treated nickel chrome steel, pressed on to its shaft and fitted with two feathers. The slow-speed shaft is of high tensile steel. Gun-metal bushes lined with white metal are used on the turbine. The rotor shaft has three bearings, end thrust being taken by those adjacent to the pinions. The slow-speed shaft has two bearings of similar construction. All are connected to the oil pressure system. Oil under a pressure of 15 lb. per square inch is sprayed on to the engaging teeth.

The turbine blades are of stainless high tensile steel with highly finished surfaces. A strainer in the steam connection protects the rotor from foreign bodies. The governor gear is completely enclosed in an oil tight case bolted to the main casing. The admission of steam to the turbine is regulated by a balanced throttle valve actuated by a servo-motor controlled by the governor, the speed of the turbine controlling the position of a distributing valve, connected with the oil pressure system by which the servo-motor is worked. The governor system has few parts and is designed so that in the event of failure of the driving shafts, steam to the turbine is at once cut off. The oil system is kept under pressure by an oil pump positively driven off the slow-speed shaft. A cooler is fitted to keep the oil at a low temperature. A strainer which can be cleaned while the turbine is running is included in the oil pressure system, pressure being kept constant by an automatic relief valve which returns surplus oil to the cooler. The oil pump is of the gear type and is located outside the main casing. The cooler will be seen in Fig. 3, in the base of the turbine unit, this forming a sump to which return oil ducts are led. Cooling water is circulated through the tubes to the amount required to suit particular conditions. The steam consumption is 18 lb. per b.h.p. hour, when operating on a pressure of 200 lb. per square inch and running at 27,500 r.p.m., condensing.

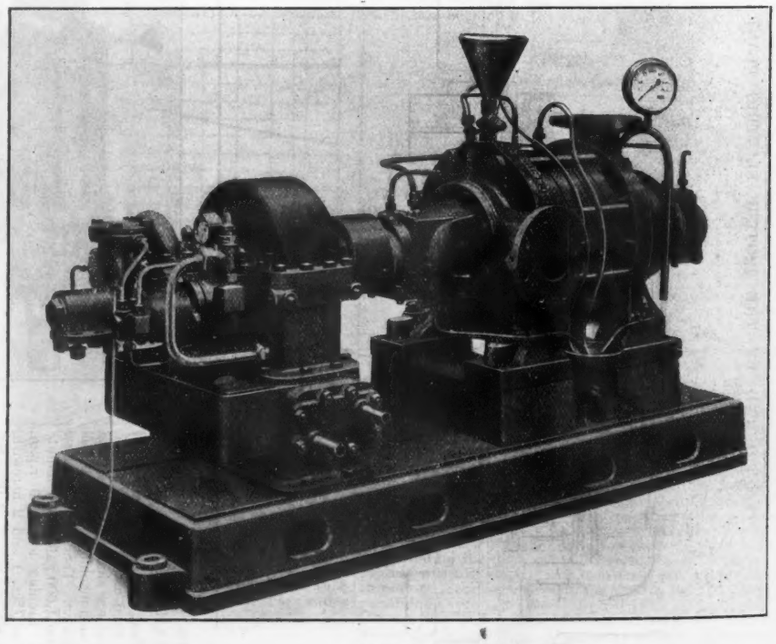
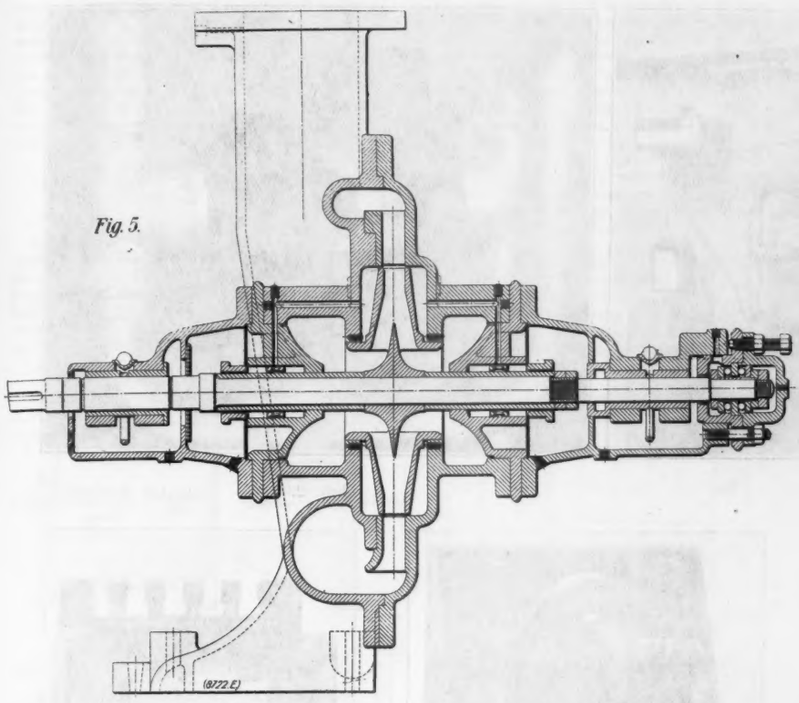


Fig. 4.

The details of construction of the pump are similar to those of the larger set described above, and need not therefore, be repeated. The connection between the pump shaft and the slow-speed shaft of the

SINGLE-STAGE CENTRIFUGAL PUMPS AT THE BRITISH EMPIRE EXHIBITION.

CONSTRUCTED BY THE BRITISH ELECTRIC PLANT COMPANY, LIMITED, ENGINEERS, ALLOA, SCOTLAND.



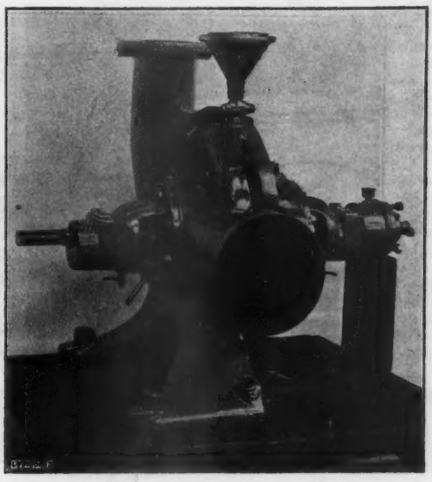
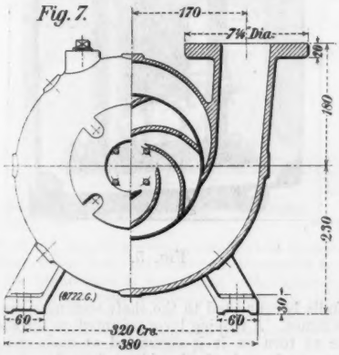
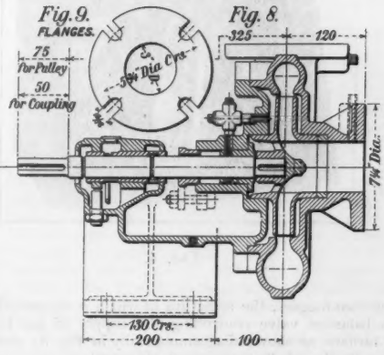


FIG. 6.





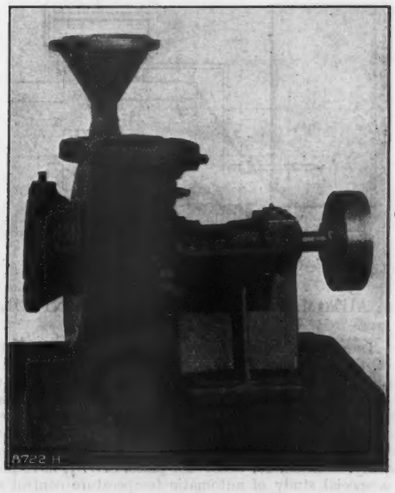


FIG. 10.

reduction gear is made by means of a pin-type flexible coupling.

The British Electric Plant Company does not confine itself to turbine pumps, but also manufactures single-stage pumps; examples which are to be seen at Wembley, are illustrated in Figs. 5 to 10, herewith. These pumps have either double entry, as in Figs. 5 and 6, or single entry, as in Figs. 7 to 10. In the former case, the volute is developed to one side of the centre line of the impeller. With these pumps, of the 6-in. size and upwards, suction and delivery branches are cast on the body, which also carries the feet. On removing the side cover the internal parts can be got at without disturbing any pipe joints, thus giving the minimum amount of trouble when reassembling. As will be seen, the removal of the cover opens the whole of the water passage for inspection. The impellers being of the double-entry type, there is no end thrust, provided the central position is maintained. A centring device, embodying a small ball bearing, is provided at one end of the shaft, as shown in Fig. 5, a gauge showing the central position. The outside bearings are ring lubricated. The guide ports are easily renewed if wear should occur.

In the single-entry pumps, as shown in Fig. 8, the thrust is towards the suction and is taken on a ring inserted between the impeller eye and the casing. Between the impeller and this renewable ring a film of water is maintained. A water seal is provided for the stuffing box, with connection to the high-pressure side of the pump, while the inner side of the stuffing box neck ring will be seen to be open to the suction side.

CATALOGUES.

Oils.—A priced list of oils for various specified purposes and a folder relating to their "Argon" engine oil are to hand from the Henry Wells Oil Company, 11, Haymarket, London, S.W.

Roller Bearings.—Line drawings illustrating the use of their roller bearings in motor-car construction have been issued in the form of leaf catalogues by Messrs. Hyatt, Limited, 56, Victoria-street, London, S.W.1.

Marine Oil Engines.—A handsomely illustrated catalogue of their two-cycle marine oil engines has come to hand from Messrs. Sulzer Brothers, 31, Bedford-square, London, W.C., giving a very full description of the construction and operation of these engines.

Electric Wiring.—British Insulated and Helsby Cables, Limited, Prescot, Lancashire, have sent us a copy of a pamphlet containing a number of illustrations of houses, cottages, churches, and public buildings, in which their twin wiring system has been installed and has given satisfactory results.

Machine Tools.—B.S.A. Tools, Limited, Sparkbrook, Birmingham, have issued a catalogue containing illustrations and particulars of several machines designed and constructed for special purposes, including multiple-drilling machines, a centreless grinding machine, and a number of single and multiple jigs.

Pneumatic Tools.—The Consolidated Pneumatic Tool Company, Limited, 170, Piccadilly, London, W.1, have sent us a catalogue of an improved design of Boyer pneumatic riveting hammer made in two sizes, one in which the piston has a 4-in. stroke and delivers 1,500 blows per minute, and the other having a 5-in. piston stroke and delivering 1,400 blows per minute. A catalogue of the firm's "Red Giant" pneumatic drill for drilling holes up to 1¼ in. diameter, or reaming up to 1 in. diameter, has also been received.

Drying Plant.—A catalogue of drying plant for laundries, received from Messrs. James Keith and Blackman Company, Limited, 27, Farringdon-avenue, London, E.C., shows a series of single and double drying rooms, draw-out horses, continuously-moving apparatus and other means of drying clothes and lengths of cloth; plant for lighting and ventilating the workrooms is also dealt with. The drying plant is supplied complete for using hot air or high-pressure gas and some examples of gas-heated hand-irons are also shown.

Switchgear.—The British Thomson-Houston Company, Limited, Rugby, have sent us four of their well arranged catalogues and lists. One of these is a catalogue of 100 pages dealing with three-phase, switchboards for standard voltage ratings of 110 to 660, 2,200, 3,300, 6,600 and 11,000. Another relates to compound-filled, truck-type switchgear, while a third gives a list of prices of mining controllers and resistances. The remaining catalogue contains information relating to direct current automatic control equipment for electrically-driven cranes.

Chain Screen for Furnaces.—The E. J. Codd Company, Baltimore, U.S.A., have sent us a catalogue relating to a fire screen especially suitable for use in glass works, but also with other furnaces, its object being to protect the workers from the glare and radiant heat. The screen is composed of steel chain hanging in single strands close together like Indian and Japanese domestic screens. The contents of a furnace, it is claimed, can be seen clearly through this chain screen, while tools can be used, and coal, ore or other material can easily be shovelled or thrown through it. The screen always falls into position after it has been moved and may be rolled up like a blind when not required. It is manufactured under patents granted to Mr. H. H. Wiegand.

AUTOMATIC TEMPERATURE-CONTROL APPARATUS; EMPIRE EXHIBITION.

CONSTRUCTED BY THE CAMBRIDGE INSTRUMENT COMPANY, LIMITED, ENGINEERS, LONDON.

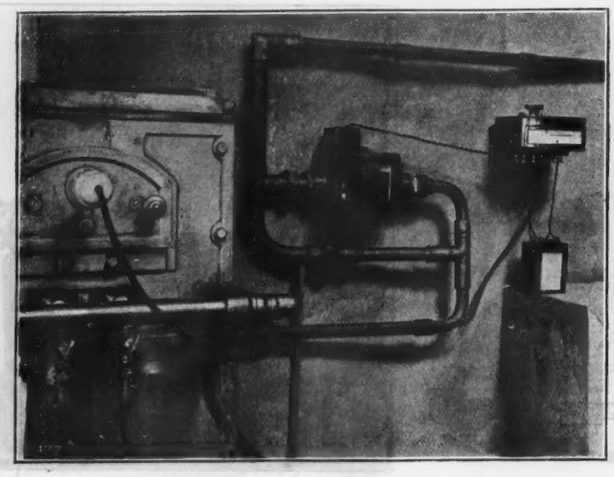


Fig. 1.

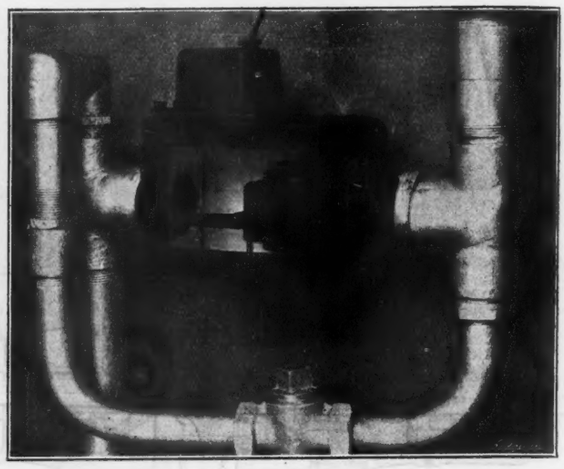


Fig. 2.

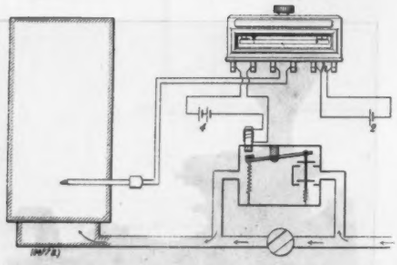


Fig. 3.

Fig. 4.

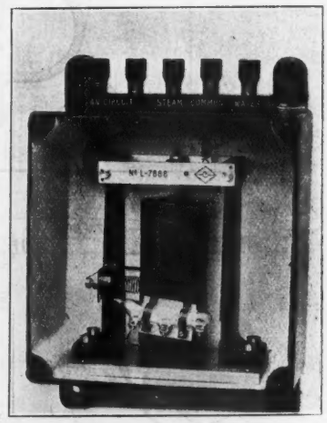


Fig. 5.

AUTOMATIC TEMPERATURE-CONTROL APPARATUS.

Increased realisation on the part of manufacturers of the necessity for accurate temperature control in industrial operations, especially in connection with the heat treatment of steel, has led to a considerable demand for apparatus designed to maintain a uniform temperature in furnaces, &c., without constant attention on the part of the operator. The Cambridge Instrument Company, Limited, 45, Grosvenor-place, S.W. 1, have made a special study of automatic temperature control and have designed and constructed apparatus to meet all the usual industrial requirements in this respect. Some examples of the class of apparatus referred to are exhibited at the firm's stand in the Palace of Engineering at the British Empire Exhibition, and others can be seen in actual operation in connection with various exhibits both in the Palace of Engineering and the Palace of Industry.

We illustrate in Figs. 1, 2 and 3, on this page, the apparatus supplied by the company for automatically controlling the temperature of a gas-fired annealing or hardening furnace. This apparatus may be regarded as typical of their current practice. Similar apparatus, with suitable modifications in detail, can be employed for controlling gas-heated or electrically-heated furnaces and ovens worked at any temperature, and also in connection with steam-heating processes. In the case of the gas-fired furnace illustrated in Fig. 1, the sensitive element is a pyrometer of the thermo-couple type, which is fitted into the furnace as shown, and connected to a millivoltmeter mounted on the wall and graduated to indicate the temperature directly. The pointer of the indicator carries a light thermo-couple, which is electrically connected to a relay of the moving-coil type, contained in the instrument case. A small heating coil, supplied with current from a 2-volt circuit, is also provided, which can be moved into any position along the scale according to the temperature it is desired to maintain in the furnace. The arrangement of the parts referred to is such that when the required temperature is reached, the thermo-couple on the pointer is brought close to the heating coil, and the electromotive force set up in the thermo-couple operates the relay. The movement of the relay completes a 4-volt external circuit, including an electro-magnet, the armature of which is connected to a balanced valve controlling the supply of gas to the furnace, as shown diagrammatically in Fig. 3; the valve itself and the necessary pipe connections are illustrated on a larger scale in Fig. 2.

It will be readily understood from Fig. 3, that when the electro-magnet is energised and the armature is pulled up, the valve will close and cut off part of the gas supplied to the furnace, although some gas is still by-passed to the furnace through the stop cock shown. The latter can be adjusted to give the requisite control, but is, of course, always opened sufficiently to prevent the flame from being extinguished when the automatic valve is closed. When the temperature of the furnace falls the thermo-couple on the pointer moves away from the heater, the electro-magnet is de-energised, and the balanced valve is reopened by means of a spring. The accuracy of temperature control possible with this arrangement, of course, depends upon the sensitivity of the pyrometer or thermometer, as well as on the character of the scale of the indicating instrument, but, when these are suitably chosen, variations not exceeding 0·5 per cent. from the normal can be guaranteed for temperatures up to 800 deg. C.

The type of valve illustrated in Fig. 2 is used for 2-in. pipes; for pipes up to 1 in. in diameter a simple ball valve is inserted directly in the pipe line. The valve shown can be employed to control the flow of low-pressure steam or liquids, as well as for gas, being suitable for pressures up to about 10 lb. per square inch. Another type of balanced valve operated by an iron core moving inside a solenoid, is used for pressures up to about 40 lb. per square inch, but for still higher pressures, where screw-down valves are necessary, the mechanism illustrated in Fig. 4 is employed. The valve itself is not visible in this illustration, but its spindle is connected to the shaft seen near the top of the figure. A rocking lever mounted on the shaft and free to turn on it is connected at each end to the plungers of a pair of solenoids, and fixed to the shaft is a disc around which are wrapped two flexible phosphor-bronze brake bands. One end of each band is connected to the end of the rocking lever, and the other end to the solenoid core on the same side of th apparatus.

The solenoids are energised through relays operated by a temperature indicator in a similar manner to that described above, and when one pair of cores is pulled down, the brake band is tightened up on the disc and the shaft rotated slightly to open or close the valve, as the case may be; one pair of solenoids is used to open the valve and the other to close it. At the end of the stroke the circuit through the solenoids is broken by means of a mercury contact mounted on the rocking lever, visible on the left of Fig. 4, and the cores are then pulled up again to their mid-position by means of springs. This operation is repeated until the valve has been opened or closed sufficiently to bring the temperature which is being controlled back to the normal. Safety contacts are provided to prevent the valve from being jammed in the fully open or completely closed positions.

As a final example of this class of apparatus, we illustrate, in Fig. 5, a device for use when very rapid control of temperature is required. In certain steam-heating operations in connection with rubber manufacture, for instance, it is necessary to turn on cold water when the steam supply is cut off, and this can be effected by the three-contact relay shown in the illustration. In this relay, platinum wires are fused into three pockets formed on the lower side of a closed glass tube containing mercury. The tube, which can

be seen near the bottom of Fig. 5, is mounted on a lever controlled by a solenoid, its normal position being such that the mercury makes a connection between the central and right-hand pockets. In this position, the water valve is closed and the steam valve open, but when the temperature of the heated vessel rises to the required degree, the solenoid is energised in the manner described above, and the tube is thus tilted so as to make contact between the central and left-hand pockets. By means of relays in the external circuits, the steam valve is then closed and the water valve opened. As soon as the temperature falls, the mercury tube returns to its original position and the normal state, with the steam valve open and the water valve closed, is restored.

HEAT LOSS IN GAS ENGINES.*

By Professor W. T. DAVID, M.A., D.Sc.

THE effect of heat loss from the working fluid of internal-combustion engines to the cylinder walls and piston upon the thermal efficiency has frequently been over-rated in the past. It nevertheless exercises an appreciable influence upon efficiency, and it is estimated that, were it possible to eliminate it altogether, an engine working on strong mixtures with an actual efficiency of, say, 35 per cent., would yield an efficiency of about 40 per cent. It is, however, impossible to over-rate its importance in connection with engine design. To it are due the costly cooling arrangements which add so greatly to the weight of the engine; and, indeed, it is the main factor limiting the development of large power units with single cylinders.

In order to gain further information in regard to heat loss, the author undertook a series of measurements of the radiation loss and of the conduction loss during the explosion and subsequent cooling of inflammable mixtures of coal-gas and air contained in a closed vessel. Two important results, from the point of view of gas-engine design, emerge from them. The first of these emphasizes the very marked influence of temperature upon the heat loss from the working fluid both by conduction and by radiation, and the other indicates that the radiation loss per unit area of wall surface increases greatly with cylinder dimensions.

CLOSED-VESSEL EXPERIMENTS.

Description of Experimental Method.—The explosion vessel consisted of a cast-iron cylinder 30 cm. in diameter and 30 cm. in length, on to which were bolted two flat end-covers. The inflammable mixtures contained in the vessel were ignited by means of an electric spark placed in the centre of the vessel. The vessel is shown in Figs. 1 and 2. In Fig. 1 the bolometer for measuring the conduction loss is shown. It consists of a grid of highly polished silver mounted upon a backing of linoleum and placed upon one of the end covers as shown in Fig. 1. The silver grid was connected with a reflecting galvanometer by means of which a curve was traced upon a revolving photographic film showing the rise of resistance of the grid as it was warmed up by contact with the hot gaseous mixtures. From this curve it is possible to calculate the heat received by conduction by the polished grid per unit area of its surface, after making an allowance for the loss to the linoleum backing. At the same time and on the same film a curve was traced by a Hopkinson optical indicator showing the rise of pressure of the gaseous mixture during explosion and subsequent cooling. From the pressure curve it is possible to deduce the mean temperature of the gaseous mixture, after making an allowance for the small contraction of volume which occurs during combustion.

The loss of heat to the walls of the explosion vessel by radiation was measured by means of a bolometer consisting of a blackened platinum grid protected from the flame by means of a fluorite window which transmits approximately 95 per cent. of the total radiation falling upon it. The fluorite window and bolometer are shown in Fig. 2. The recording arrangements were similar to those employed for the conduction measurements. Curves of loss of heat by radiation and of pressure were recorded on the same photographic film.

Experimental Results.—The results of one set of experiments are shown in Fig. 3. These relate to a 15 per cent. mixture of coal-gas* and air exploded at atmospheric temperature and density. The T curve gives the mean gas temperature at various times after ignition; it has been deduced from the pressure record by means of the characteristic equation $pv = RT$, after allowing for a contraction of volume of nearly 4 per cent., which takes place during combustion. The R curve gives the mean loss of heat by radiation per square centimetre of wall surface, and the C curve gives the mean loss by conduction per square centimetre. The H curve is the sum of the R and C curves, and gives the total heat loss per square centimetre of wall surface.

The total heat loss over a given interval of time (say half-a-second after ignition) appears to be very approximately proportional to the square of the maximum absolute temperature attained during the explosion. This may be seen from the last column in Table I, in which the total heat lost over the interval half-a-second from ignition has been divided by the square of the maximum absolute temperature attained from the various mixtures.

TABLE I.

Mixture.	Max. Abs. Temp. $T_{max.}$	Total Heat Loss per Sq. Cm.	Total Heat Loss Over Entire Surface of Vessel.	Total Heat Loss / $T^2_{max.}$
Per cent.	° C. Abs.	Calories.	Calories.	
15·0	2,440	2·37	10,380	$1{\cdot}75\times10^{-3}$
12·4	2,050	1·71	7,500	$1{\cdot}78\times10^{-3}$
9·7	1,660	1·13	4,950	$1{\cdot}79\times10^{-3}$

The dotted curves R′, C′, and H′ in Fig. 3, are the differentials of the heat loss curves R, C and H. They give the rate of heat loss by radiation (R′), by conduction (C′), and total (H′) per square centimetre of wall surface per second.

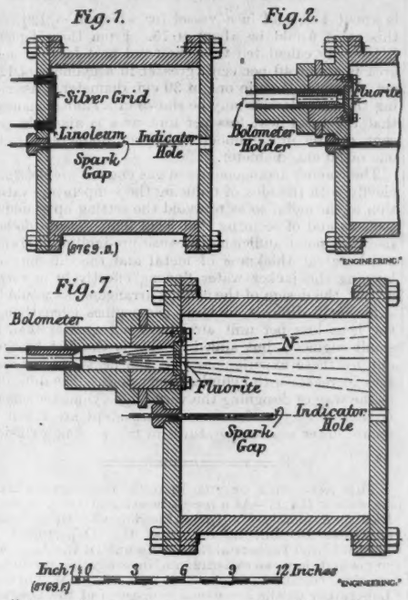
The rate of heat loss per square centimetre by radiation, by conduction, and the total in terms of the mean gas temperature is shown for the various mixtures in Fig. 6. An examination of the curves in this figure shows that the rate at which heat loss goes on varies very approximately as the fourth power of the absolute temperature of the hot gaseous mixture, both in the case of radiation and conduction.

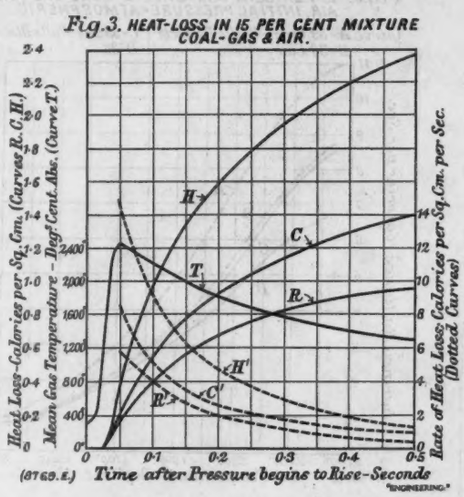
Further Study of the Radiation Loss.—The conduction loss is, on the average, about 50 per cent. greater than the radiation loss in the various mixtures. This applies, however, only in the case of explosion vessels of the size used in these experiments. For any given temperature difference between the gas and the walls, the rate of loss by conduction per unit area of wall surface is practically independent of the dimensions of the vessel, but further experiments have shown that the rate of radiation loss per unit area is very much dependent upon the dimensions of the vessel as well as upon the temperature of the hot gaseous mixtures. These experiments will now be described. They were made with the same explosion vessel as was used for the previous experiments, but its interior surface was silver-plated and could therefore be made either absorbent as regards radiation by coating with a thin layer of dull black paint, or reflecting by polishing. The bolometric arrangements were as shown in Fig. 7. The bolometer was removed to some distance behind the fluorite window so that it "saw" only the cone of gas indicated in the figure. The radiation values measured in this way have been divided by the solid angle of the cone of gas so as to give the radiation from a cone of unit solid angle. The radiation received by unit area of bolometer surface per second from a cone of gas of unit solid angle has been termed by Professor Callendar the *intrinsic radiance*.

The experiments consisted essentially in investigating the effect upon the intrinsic radiance of varying both the thickness of the radiating layer of gas (that is, the length of the cone) and the lateral dimensions of the volume of gaseous mixtures of which the cone forms a part. They were made with 15 per cent. mixtures of coal-gas and air at atmospheric density. The results of the experiments are summarized in the curves in Fig. 9. The approximate conditions under which each set of experiments, represented by the curves in this figure, were made, may be seen on reference to Fig. 8. The full line square M N O P represents a longitudinal section of the explosion vessel (which was 30 cm. in diameter and 30 cm. in length), and when the walls of the vessel were painted black, the cone of gas "seen" by the bolometer was as shown by the thin lines. Under such conditions the intrinsic radiance curve D, Fig. 9, was taken. It shows the intrinsic radiance from a cone of gas of thickness 30 cm. at various temperatures from the maximum developed down to 1,300 deg. C. abs., when it constitutes a portion of a cylindrical volume of gaseous mixture of the dimensions of the experimental vessel.

In the next set of experiments, the end-cover N O, Fig. 8, was highly polished, and therefore made reflecting as regards the radiation falling upon it from the hot gaseous mixture; the remainder of the cylinder was blackened. By this means, the length of the cylinder was virtually nearly doubled,* as shown by the rectangle M N_1 O_1 P, Fig. 8, and therefore the virtual length of the cone of gas was nearly doubled. The results of the experiments made under the conditions are shown by curve C, Fig. 9. This curve therefore shows the intrinsic radiance from a cone of the gaseous mixture approximately 59 cm. in length when it forms part of a cylindrical volume of gaseous mixture 30 cm. in diameter and 59 cm. in length.

On comparing curves C and D, it will be noticed that





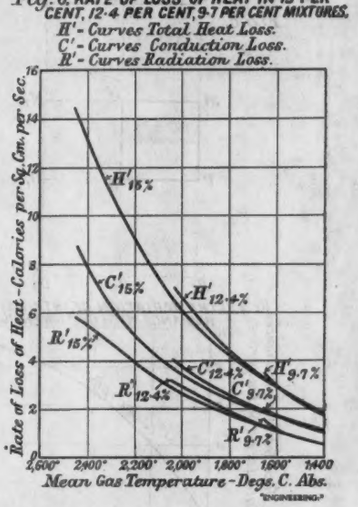


Fig. 6. RATE OF LOSS OF HEAT IN 15 PER CENT, 12·4 PER CENT, 9·7 PER CENT MIXTURES.
H'-Curves Total Heat Loss.
C'-Curves Conduction Loss.
R'-Curves Radiation Loss.
Rate of Loss of Heat-Calories per Sq. Cm. per Sec.
H' 15%
C' 15%
H' 12·4%
R' 15%
C' 12·4%
H' 9·7%
C' 9·7%
R' 12·4%
R' 9·7%
2,600° 2,400° 2,200° 2,000° 1,800° 1,600° 1,400
Mean Gas Temperature-Degs. C. Abs.
"ENGINEERING."

* Paper, abridged, read before the Institution of Mechanical Engineers on Friday, October 24, 1924. The Author's numbering of the figures has been retained.

* For composition of coal-gas, see Appendix to previous paper (page 624).

* Highly polished silver reflects about 98 per cent. of the radiation falling upon it. The virtual length of the cylinder was therefore about 59 cm.

the intrinsic radiance from a layer of gaseous mixture 59 cm. thick is, at the high temperatures, more than 20 per cent. greater than that from 30 cm. of the gaseous mixture when measured under similar conditions of temperature and lateral dimensions. This clearly shows that the gaseous mixture is highly transparent to radiation of the same kind as it emits, and that the heat loss by radiation to the walls of an engine cylinder is therefore very much dependent upon the thickness of the layer of radiating gas.

In the next series of experiments, the cylindrical surface was polished, the two end covers remaining black. By this means the cone of the gas from which the radiation was measured was a portion of a virtual volume of gaseous mixture of a very great lateral dimensions, though it was only 30 cm. in length, as shown by the rectangle M_2 N_2 O_2 P_2, Fig. 8. The intrinsic radiance measurements under these conditions are given by curve B, Fig. 9. These are remarkable results. In view of the fact that the radiation measured by the bolometer came only from the small cone of gas of length 30 cm., it would have been expected that the radiation measured at any given temperature would have been the same as in the first series of experiments (curve D). These results, as further experiments have shown, are due to two causes: in the first place, an increase in the lateral dimensions

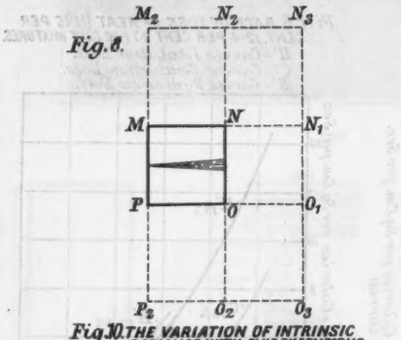


Fig. 8.

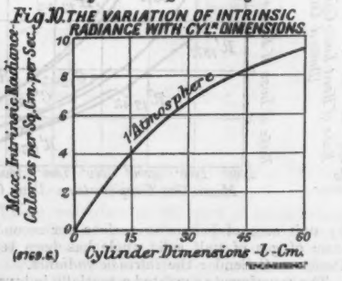


Fig. 10. THE VARIATION OF INTRINSIC RADIANCE WITH CYL.R DIMENSIONS.

causes the gaseous mixture to be more transparent, and, in the second place, the vibratory energy of the molecules which give rise to radiation is, at any given temperature, very much dependent upon the volume, or virtual volume, of the gaseous mixture of which they form a part.

The last series of experiments were made with the cylindrical surface of the vessel, and the end cover opposite the bolometer, highly polished.* The results of these experiments are shown by curve A, Fig. 9 In this case, the cone of gas formed part of a virtual volume of gas of lateral dimensions equal to those in the third series of experiments, but its virtual length was 59 cm. (that is, nearly double that in the third series). The virtual volume in this series is indicated by the rectangle M_1 N_1 O_1 P_1 (Fig. 8). It will be noticed that the intrinsic radiance is much greater in this series of experiments, a result which was to be expected from a study of the first, second and third series.

The data provided by these experiments enable one to formulate the relationship between the intrinsic radiance and the cylinder dimensions, and in Fig. 10 it is shown how the intrinsic radiance at the maximum temperature developed in these experiments varies, in a cylinder l cm. in diameter and l cm. in length, with l. An examination of the curve shows that the intrinsic radiance varies very approximately as $\sqrt{l}$. Thus, while the conduction loss from the hot gaseous mixture at any given temperature over the entire surface of the vessel varies as l^2 (since the conduction loss per unit area of wall surface is independent of the cylinder dimensions), the loss of heat by radiation from the hot mixture at any given temperature over the entire surface of the vessel varies as $l^2 \times \sqrt{l} = l^{\frac{5}{2}}$.

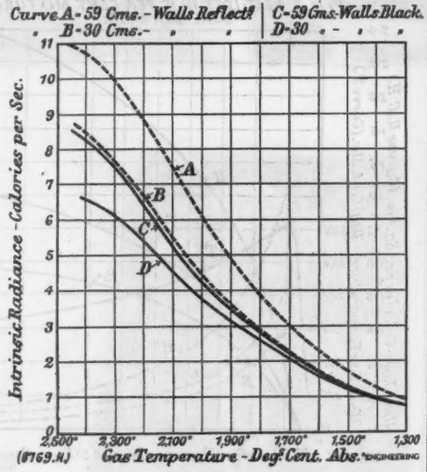
* A portion of the end-cover holding the bolometer was also polished, but this was not sufficient to affect the results materially.

In internal-combustion engines, the densities and pressures of the working fluid are, of course, much greater than in these experiments. It was not possible to undertake a series of experiments at such high densities on account of the fact that the fluorite window would not have stood the pressures which would have been developed. Similar experiments were, however, undertaken in which the density was varied from half an atmosphere to one and a-quarter atmospheres and the general character of the results was precisely similar, excepting, of course, that the intrinsic radiance under any given conditions of temperature and dimensions increased with the density; in fact, it varied very approximately as the square root of the density.

Application of Experimental Results to the Gas Engine.

The Influence of Temperature upon Heat Loss.—The bearing of these experiments upon the loss of heat from the working fluid in internal-combustion engines will be obvious. In the first place, they show that, in any given engine, the rate of loss at high temperatures varies approximately in proportion to the fourth power of the absolute temperature, both in respect of the conduction loss and in respect of the radiation loss. In passing, it may be pointed out that in neither

Fig. 9. IS PER CENT MIXTURES OF COAL-GAS AND AIR, INITIAL PRESSURE-ATMOSPHERIC.



case could these results have been predicted from known physical laws. It is generally assumed that the conduction loss varies as the temperature difference between the hot gaseous mixture and the cylinder walls, whereas the radiation loss would have been expected to vary more or less according to Planck's equation for the energy in a single wave-length, in view of the fact that the radiation from the hot gaseous mixture does not constitute a continuous spectrum but is concentrated mainly in two bands whose maxima are of wave-length 2·8 μ and 4·4 μ approximately.

While the experiments bring home the very great influence of temperature both upon the conduction loss and upon the radiation loss and thus lend special emphasis to the importance of working with as low temperatures as is consistent with obtaining a reasonable output per unit weight of engine, their direct application to the determining of the heat loss from, say, an indicator diagram at each stage during the cycle would be a laborious process. But a further examination of the closed-vessel experiments suggests the possibility of building up a simple expression which may be easily applied to the diagram. It will be remembered that the total heat loss during a period of, say, half-a-second from the moment of ignition was found to be very approximately proportional to the square of the absolute maximum temperature developed ($T^2_{max.}$), and it would seem, therefore, that a formula of the type $K T^n_{max.}$ should give reasonably reliable information in regard to the total heat loss during the explosion-expansion stroke, K being a constant for any given engine working at a constant speed and $T_{max.}$ the maximum absolute temperature developed, which varies, of course, with the strength of the charge. From data furnished by the experiments of Clerk, Coker and Scoble, Burstall and Walker, n is found to vary between 2 and about 2·2, and for purposes of approximate calculation sufficiently accurate results are obtained by taking $n = 2$.

The expression $K T^n_{max.}$ appears to apply equally for any given engine, both to the heat loss during the explosion-expansion stroke and to the heat loss as measured by the cooling water; though the value of K would, of course, be different in the two cases on account of the fact that the heat loss as measured by the cooling water includes not only the heat loss during the explosion-expansion stroke but also the heat loss during the exhaust which takes place as the hot gases rush past the exhaust-valve.

Effect of Cylinder Dimensions upon Heat Loss.—The fact that the radiation loss per unit area in the closed-vessel experiments increases with the size of the vessel, shows that the heat loss per unit area of wall surface increases with cylinder dimensions in the case of gas-engines working under similar conditions of mixture strength and speed. The heat loss per unit area in similar engines working under similar conditions may be calculated approximately from the equation

$$H = C + R\sqrt{d},$$

where C is the conduction loss per unit area and $R\sqrt{d}$ is the radiation loss per unit area in a cylinder of diameter d. Some idea of the way in which H may vary with d in actual engines may be obtained from the closed-vessel experiments if it is assumed that the ratio between the conduction and the radiation loss in any given vessel does not vary very much with the density. The ratio $\frac{C}{R\sqrt{d}}$ in the experimental vessel ($d = 30$ cm.) is about 1·5, and in a vessel for which $d = 120$ cm. this ratio would be about 0·75. From these figures it is easily calculated that the total heat loss per unit area is about 40 per cent. greater in a cylinder of 120 cm. diameter than in one of 30 cm. diameter. Assuming the same law, it may be shown in a similar manner that the total heat loss per unit area is about 50 per cent. greater in a cylinder of 150 cm. diameter than in one of 30 cm. diameter.

The cooling arrangements in gas engines are designed chiefly with the idea of reducing the temperature variation in the metal so as to avoid the setting up of undue stresses and of securing that local temperatures do not rise to a point sufficient to cause pre-ignition. Owing to the great thickness of metal and the difficulty of keeping the jacket water flowing effectively in every corner, the design of the cooling arrangements would be sufficiently difficult in large gas-engines even though the heat loss per unit area were not greater than in small engines; but added to this is the fact brought out by these experiments that the heat loss per unit area increases with cylinder dimensions. The difficulty in the way of designing the very large cylindered engine is thus a very serious one unless steps are taken to secure lower gas temperatures in the working cylinder.

The Acoustics of the League of Nations New Assembly Hall.—At a recent meeting of the League of Nations Assembly, Sir Hubert Llewellyn Smith, on behalf of Great Britain, offered that the Department of Scientific and Industrial Research would, if the Assembly so desired, have an experimental investigation conducted at this country's expense at the National Physical Laboratory on the acoustical properties of the League's proposed hall. This offer was accepted.

Steel Wire.—In a paper read before the Institution of Welding Engineers on October 23, 1924, Mr. E. A. Atkins described the manufacture of steel wire and various of its uses. He said that the method of drawing was apparently invented at Augsberg or Nurnberg about the middle of the fourteenth century and was apparently introduced into England about the middle of the fifteenth century. In the early days, best iron was used for wire, but steel is almost invariably used to-day though a little Swedish charcoal iron is still drawn. The material was prepared for drawing by rolling into rods about $\frac{1}{4}$ in. in diameter. These were then pickled in hydrochloric acid to remove scale, which was fatal to good wire drawing. After pickling, the rods were washed and allowed to stand until they "browned"; that was to say until they became coated with a thin film of ferric-hydrate. This coating was most important. After this, the rods were dipped in hot lime water and then dried in an oven. A thin coating of lime was thus produced on top of the hydrate layer which protected the latter and prevented corrosion of the rod. Two methods of drawing were in vogue, the "dry" method and the "wet" method. In dry drawing, the rod is passed through a drawplate having a tapered hole, the lubricant used being well-dried soap. In wet drawing, the rod was first coated with copper by immersion in a solution of copper sulphate. It was next passed through a soap solution and then to the hole in the drawplate. This method of wire drawing a hard metal within a shell or skin of softer metal gave very good results. The speed of drawing might be as much as 1,000 ft. per minute in the case of soft steel. In the process, the tensile strength of the metal was enormously increased, a rod having a tensile strength of, say, 33 tons per square inch, yielding wire of No. 16½ gauge with a tensile strength of 62 tons per square inch. By annealing this and further drawing it down to No. 33 gauge the tensile strength was raised to 85 tons per square inch. Similarly, a 0·75 carbon-steel rod, with a tensile strength of 57 tons per square inch, yielded 33 gauge wire with a tensile strength of 200 tons per square inch.